SEWAGE AND INDUSTRIAL WASTES

(Formerly Sewage Works Journal)

JOURNAL of the FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS

Special Features

Biocatalysts in Digestion—Grune and Sload

Elutriation at Bay Park Plant—Sparr

Oxidation of Sludge with Oxygen—Abel et al.

Process Operations and Waste Control—Dickerson

Industrial Sewer Modifications—Swartz

1954 Annual Index

DECEMBER, 1954—VOL. 26, No. 12

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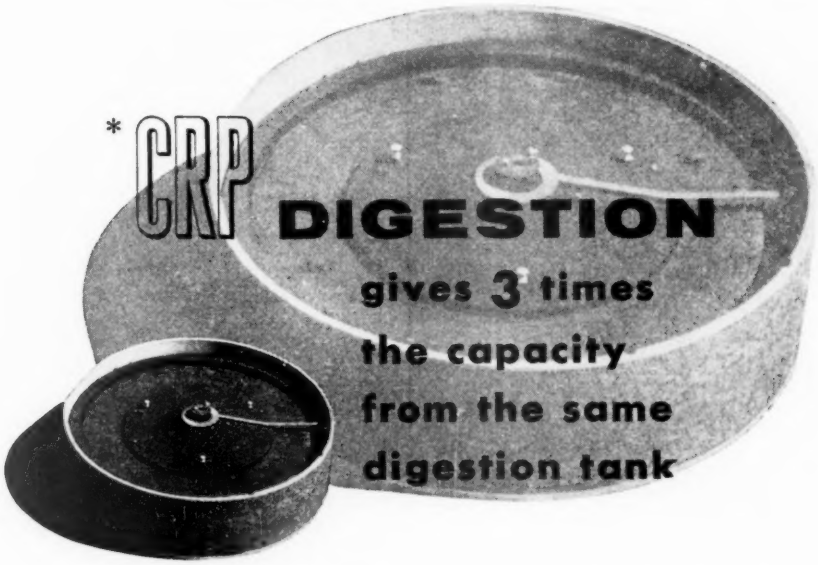
Please remit directly to your Member Association Secretary immediately upon receipt of the first dues notice from him.



CATALYTIC REDUCTION PROCESS* Triples Sludge Digestion Rate to Boost Digestion Tank Capacity

The CATALYTIC REDUCTION PROCESS is the only proved process for accelerating biological digestion. Originating in 1946, the PROCESS was developed, tested and verified over six years on both laboratory and plant scale. The results have been proven in full scale plant operation at the Columbus, Ohio and Erie, Pennsylvania Sewage Treatment Plants. The PROCESS is now being installed in seven other cities.

DETAILS OF ONE TEST

The CATALYTIC REDUCTION PROCESS applied to one 70′ tank at the Columbus Plant digested 3.38 times the quantity of sludge solids digested in a similar tank in parallel operation not using the PROCESS. The tank operating under the PROCESS produced a reduction of solids within established ranges, normal gas production and readily driable odorless sludge.

PREVENTS FLOATING DIGESTIBLE SOLIDS

By providing accelerated digestion, the CATALYTIC REDUCTION PROCESS offers the only fundamental and satisfactory method for preventing deep surface accumulation (sometimes mistakenly called scum) of digestible solids that are symptomatic of inadequate digestion. CRP simultaneously accelerates and uniformly digests ALL digestible solids.

Reports Available

Reports describing the PROCESS in detail are available on request. Write:

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CHICAGO PUMP COMPANY

Subsidiary of Food Machinery and Chemical Corporation

SEWAGE EQUIPMENT DIVISION

622 DIVERSEY PARKWAY • CHICAGO 14, ILLINOIS

Flush Kleen, Screw-Feeder, Plunger, Horizontal and Vertical Non-Clog Water Seal Pumping Units, Sumpless.

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SEWAGE AND INDUSTRIAL WASTES

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A monthly Journal devoted to the advancement of fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of such works.

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Model DVS manually controlled Chlorinizer installed at Estacada, Oregon — Supt. Glen Ebert at left, Mayor Ford A. Darrow, at right.

CHLORINIZER Made a Big Difference in the Small Town of Estacada, Oregon

For the 1,000 people of Estacada, this Builders Model DVS Chlorinizer represents an important municipal economy. Previously another type of equipment had cost up to $10.00 a month in heating bills alone to overcome a serious "chlorine ice" problem. With the Chlorinizer, safe and dependable chlorination has been maintained even when water temperature dropped to 33°F. and air temperature stood at 17°F. . . . further proof of the advantage of metering and controlling chlorine gas in the dry, inert state.

Since early 1953 when the installation was made, the Chlorinizer has been in service continuously, and has required almost no maintenance. In a town of this size, municipal budgets cannot afford specially trained chlorination maintenance men. The Chlorinizer has operated since installation completely without need for specialized personnel

More and more, the trend is to Chlorinizer, for new projects, for replacement, for plant expansion. Find out for yourself why this safe, simple, dependable chlorine gas feeder will save you money and serve you well. Write for descriptive Bulletins. Builders-Providence, Inc., 368 Harris Avenue, Providence 1, Rhode Island.

Mayor Ford A. Darrow of Estacada, Oregon states, "We had considerable trouble with another make . . . and to date have had no trouble with Chlorinizer. We are entirely satisfied and would recommend this chlorine gas feeder".

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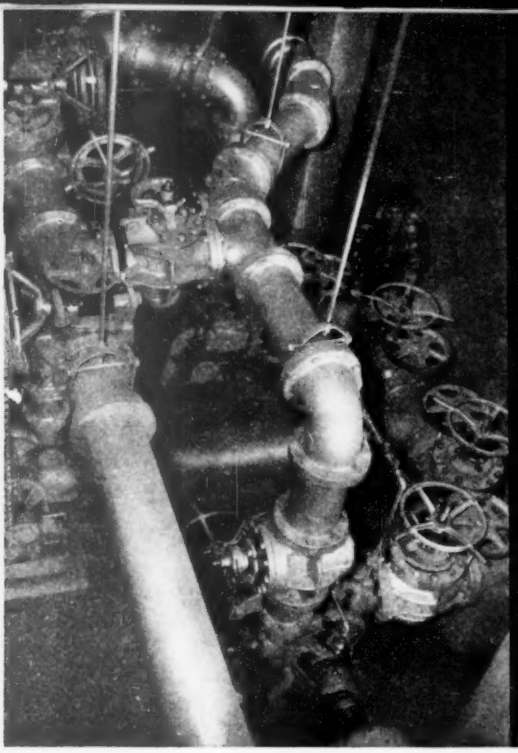
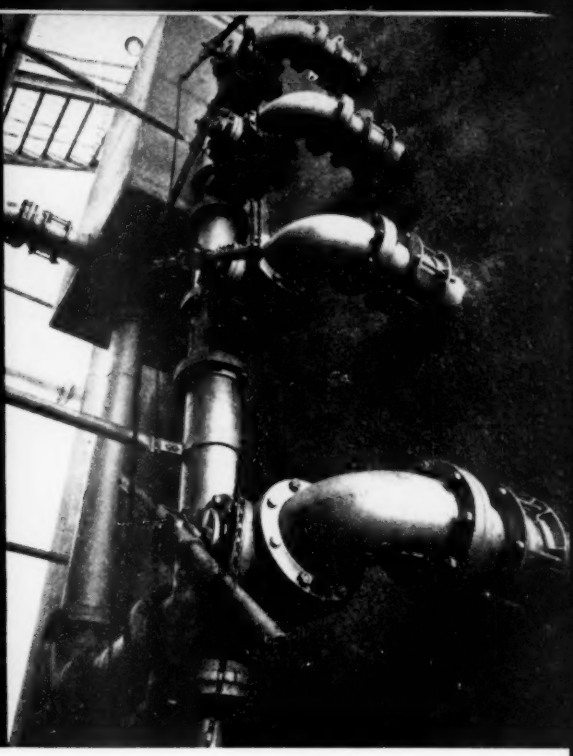
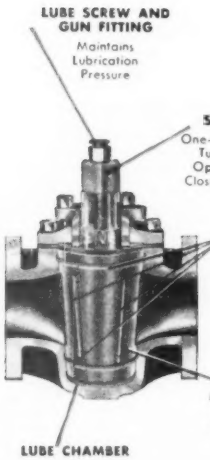




Simplify Sewage Plant Installation Problems with *Versatile* ROCKWELL-Nordstrom VALVES!


LUBE SCREW AND GUN FITTING
Maintains Lubrication Pressure
STEM
One-Quarter Turn To Open Or Close Valve
LUBE CHANNELS
A Perfect Seal . . . Cut-Offs Prevent Leakage Into Line
TAPERED PLUG
Maximum Strength . . . Perfect Seating . . . Seat Never Exposed
LUBE CHAMBER
If Necessary, Jacks Plug For Easy Operation . . . Eliminates Stuck Valves

Rockwell-Nordstrom valves are ideal for the complex piping in modern sewage plants because they not only give you traditional Nordstrom dependability, but also unusual *flexibility* for accessory operation. The rotary plug action means closure in a quarter turn which permits simpler, more rugged operating mechanisms. They operate equally well in any position. Using chain wheel or double end chain wrenches you have fast, dependable control of overhead valves. Spur gear and worm gear operated valves respond instantly, smoothly, because Rockwell-Nordstroms are *pressure lubricated.* The absence of bulky, heavy bonnet cavities means real space economy, too. In areas inaccessible to the operator, floor stands and high head extensions give complete freedom in valve placement. For underground services, Rockwell watertight gear housings slash costs by eliminating special boxes or vaults.

Look at the features shown in the cutaway drawing and you'll see why Rockwell-Nordstroms are not only the most versatile, but the most *efficient* valves for every service from water to sludge treatment chemicals. Write for Bulletin C-5200 today. Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES *Lubricant-Sealed for Positive Shut-Off*

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Association	*Place*	*Time*
New York Sewage and Industrial Wastes Assn.	Hotel Belmont Plaza, New York, N. Y.	Jan. 20–21, 1955
Texas Water and Sewage Works Assn.	Texas A. and M. College, College Station, Texas	March 6–11, 1955
Arizona Sewage and Water Works Assn.	San Marcos Hotel, Chandler, Ariz.	April 14–16, 1955
California Sewage and Industrial Wastes Assn.	Mission Inn, Riverside, Calif.	April 27–30, 1955
Iowa Sewage Works Assn.	Hotel Waukonsa Fort Dodge, Iowa	Sept. 7–9, 1955
Kentucky–Tennessee Industrial Wastes and Sewage Works Assn.	Phoenix Hotel Lexington, Ky.	Sept. 12–14, 1955

TWENTY-EIGHTH ANNUAL MEETING

Federation of Sewage and Industrial Wastes Associations

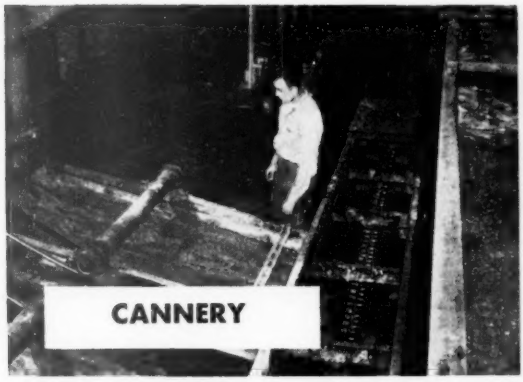
in conjunction with

New Jersey Sewage and Industrial Wastes Association

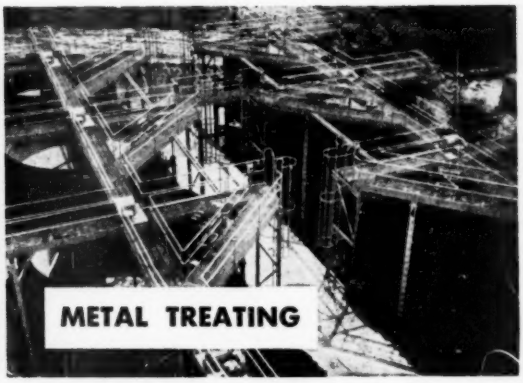
Ambassador Hotel, Atlantic City, New Jersey

October 10–13, 1955

Whether waste presents PROBLEMS...



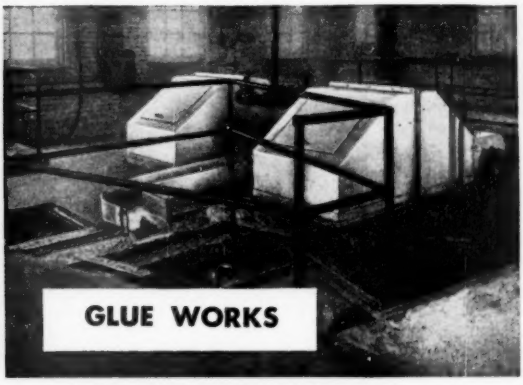
Link-Belt Thru-Clean Bar Screen, Straightline Grit Collector, flight conveyor and two liquid vibrating screens remove solids from waste water at midwest cannery.



Link-Belt flash mixers and thickener unit help separate toxic metals and cyanides from waste waters. Sludge thickening affords considerable savings in hauling costs.

or potential PROFITS...

Here profits were literally "going down the drain." But with Link-Belt Straightline Collectors installed, mill scale recovery rose from 250 to 475 tons per week.



Link-Belt Straightline Collector and Rotoline scum skimmer provide more efficient collection of solids, resulting in substantial reclaiming of grease and usable glue stock.

LINK-BELT knows how best to treat it

REGARDLESS of the nature of your waste . . . the size of your operations—Link-Belt experience and equipment assures a treatment system suited to your needs. If by-products are salvageable, Link-Belt can bring you maximum profits. Or if fast, low-cost waste treatment is the prime consideration, your answer lies in the job-proven efficiency of Link-Belt equipment. A call to your nearby Link-Belt office will put you in touch with a sanitary engineer. He's ready to work with your consultants and chemists—help you get the best in modern industrial liquids, water or sewage treatment equipment.

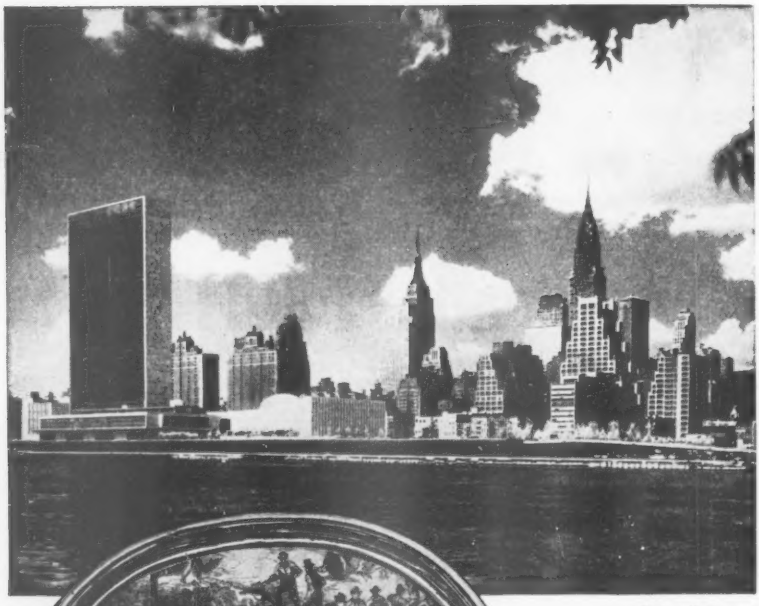
LINK-BELT

SANITARY ENGINEERING EQUIPMENT

13.632

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

With 100 years



Ewing Galloway

This is New York, as seen from East River, showing Empire State, Chrysler and United Nations buildings.

Bettmann Archive

Old print showing cast iron water mains being installed in New York about 100 years ago.

MODERNIZED **cast iron**

# of EXPERIENCE... they must be right!

NEW YORK installed cast iron water mains 100 years ago... and installs them today!

One hundred years ago, New York was a city of about 750,000 population, served by 237 miles of water mains. Today's eight million population requires 5500 miles of mains, of which 98% are cast iron. Some of these mains are still functioning after a century and more of service. From 90 M.G.D. a century ago, capacity has grown to 1500 M.G.D.

In good condition after 100 years of service, this cast iron distribution main is one of several still functioning in New York City.

A customer who buys your product year after year—generation after generation—is a "jewel beyond price". Be you merchant or manufacturer, you might count such customers on the fingers of your two hands. Yet, the cast iron pressure pipe industry can count more than 60 of them—utilities that have been buying cast iron pipe for water or gas mains (or both) for 100 years.

Cast iron pipe has been a rugged, long-lived product from the earliest days. Today's *modernized* cast iron pipe, centrifugally cast, is even stronger, tougher, and more uniform in quality. And, where needed and specified, it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout the long life of the pipe.

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.

CAST IRON

The Q-Check stenciled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

pipe FOR MODERN WATER WORKS OPERATION

Two Bests

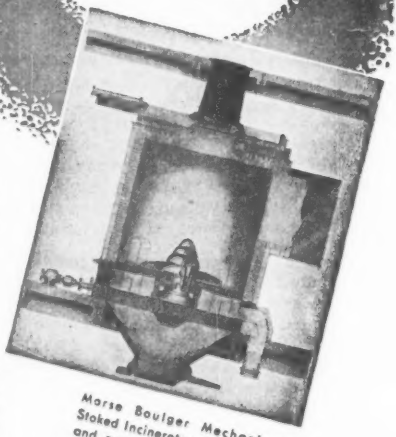
1
WASTE DISPOSAL
BY
INCINERATION

2
INCINERATORS
BY
SPECIALISTS

Select from this list of five different types and you will get the best type for your particular problem whether it is trash, garbage, sewage sludge, institutional organic matter . . . separately or in combination.

- For Garbage and Rubbish
  - (1) Cell and Hearth
  - (2) Circular Hearth and Grate—Mechanically Stoked
- For Sewage Sludge Drying and/or Burning
  - (3) Multiple Zone Furnace—Mechanically Stoked
- For Garbage, Rubbish and Sewage Sludge
  - (4) Circular Unit, Mechanically Stoked, with Separate Compartment for Sewage Sludge Reduction
- For Garbage and Trash (Individual Buildings)
  - (5) Kernerators (Flue-Fed and Ready-Built)

Our incinerator experience goes back nearly sixty years. Our work is guaranteed. Our incinerators are constructed under the supervision of our own field men who stay with it until the unit is in operation, fully broken in and crews instructed.



Morse Boulger Mechanically Stoked Incinerator, circular hearth and grate, for garbage, rubbish and all kinds of industrial wastes.

MORSE BOULGER DESTRUCTOR CO.

205-S East 42nd St. New York 17, N. Y.

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Aerial view of the Kansas City, Kansas Works, Fairbanks, Morse & Co., 3601 Kansas Avenue.

...from Kansas City

Yes, from our new, modern-as-tomorrow works at Kansas City, we serve the world's need for pumps, engines and oil field equipment.

As a major supplier of pumping equipment, it is particularly suitable that Fairbanks-Morse be located at an important crossroads of the world... Kansas City. In this new plant 190,000 square feet of manufacturing space and a complete foundry occupying 150,000 square feet are devoted to bringing better service to our customers all over the world.

Modern manufacturing, development and testing equipment backed by the design, engineering and production skills of highly trained personnel combine to produce products of unmatched quality... in performance, durability, economy. Fairbanks, Morse & Co., Chicago 5, Ill.

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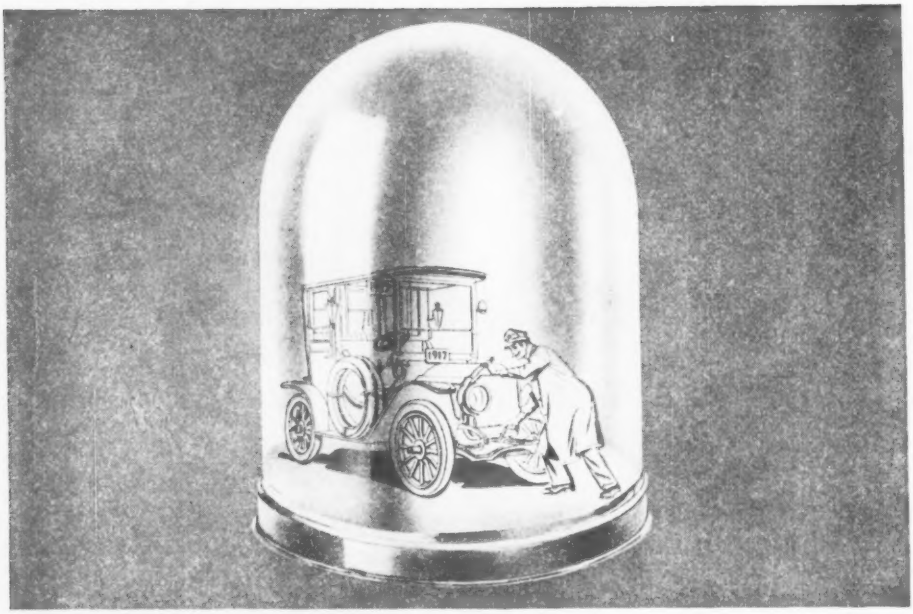

how much does it cost . . . to "crank" an old style chlorinator?

The automobile self-type starter isn't news any more — nobody ever cranks a car these days. "Cranking" an old-style chlorinator is equally out-dated.

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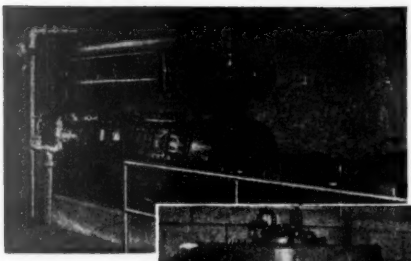

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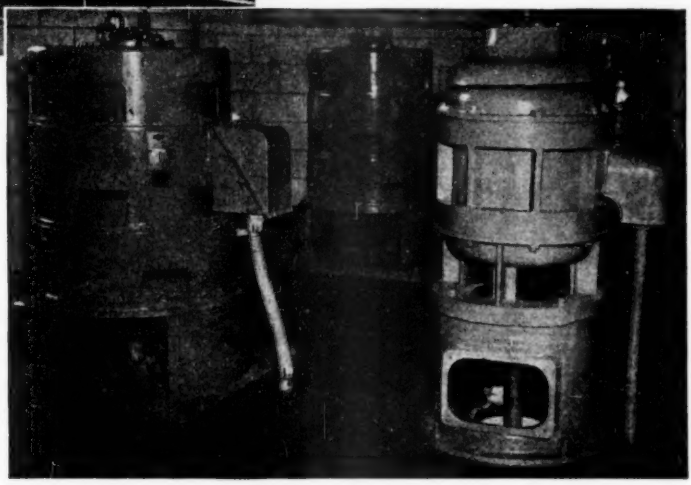

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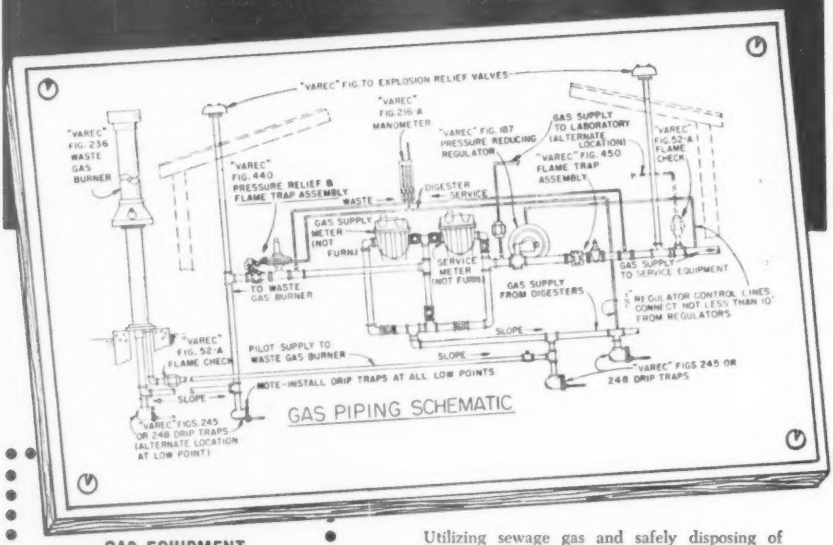
"VAREC" FIG. 70 EXPLOSION RELIEF VALVES
"VAREC" FIG. 216-A MANOMETER
"VAREC" FIG. 187 PRESSURE REDUCING REGULATOR
GAS SUPPLY TO LABORATORY (ALTERNATE LOCATION)
"VAREC" FIG. 450 FLAME TRAP ASSEMBLY
"VAREC" FIG. 52-A FLAME CHECK
"VAREC" FIG. 236 WASTE GAS BURNER
"VAREC" FIG. 440 PRESSURE RELIEF & FLAME TRAP ASSEMBLY
WASTE
DIGESTER SERVICE
GAS SUPPLY METER (NOT FURN.)
SERVICE METER (NOT FURN.)
GAS SUPPLY TO SERVICE EQUIPMENT
TO WASTE GAS BURNER
GAS SUPPLY FROM DIGESTERS
"REGULATOR CONTROL LINES" CONNECT NOT LESS THAN 10' FROM REGULATORS
"VAREC" FIG. 52-A FLAME CHECK
PILOT SUPPLY TO WASTE GAS BURNER
SLOPE
SLOPE
"VAREC" FIGS 245 OR 248 DRIP TRAPS
NOTE-INSTALL DRIP TRAPS AT ALL LOW POINTS
SLOPE
"VAREC" FIGS 245 OR 248 DRIP TRAPS (ALTERNATE LOCATION AT LOW POINT)
GAS PIPING SCHEMATIC

GAS EQUIPMENT SPECIFICATIONS

PRESSURE RELIEF AND FLAME TRAP ASSEMBLY
"VAREC" Fig. No. 440

FLAME TRAP ASSEMBLY
"VAREC" Fig. No. 450

FLAME CHECK
"VAREC" Fig. No. 52A

EXPLOSION RELIEF VALVES
"VAREC" Fig. No. 70-1

WASTE GAS BURNER
"VAREC" Fig. No. 236

DRIP TRAPS
"VAREC" Fig. No. 245 (automatic)
"VAREC" Fig. No. 248 (hand operated)

MANOMETERS
"VAREC" Fig. No. 216A

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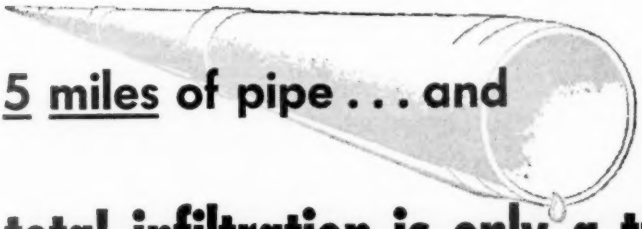

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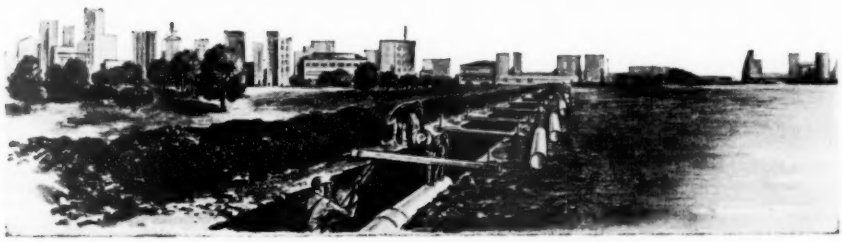

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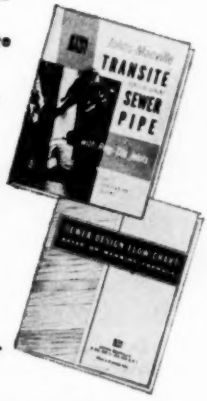

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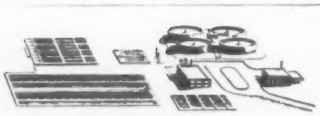
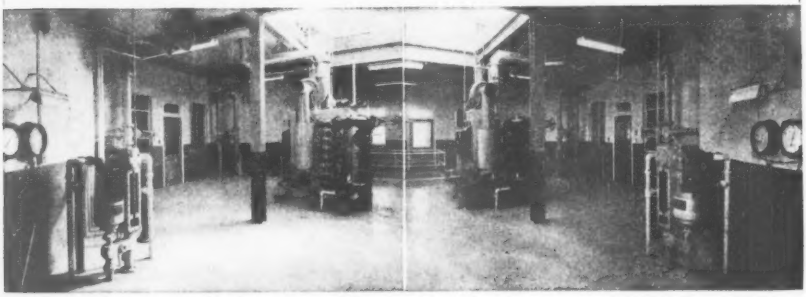


At Levittown, Pennsylvania *a large city grows. According to Reader's Digest, this is one of the fastest-growing communities in the world. Their modern sewage plant was designed by Albright & Friel, Inc. with Levitt & Sons' Sanitary Engineer, F. J. Biele.*



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The control chamber is ideally housed . . . surrounded by the four 55-foot digesters. *P.F.T. Cover Position Indicator Dials* (with low-level alarms) flank each side of the room. An operator may see the exact position of the *P.F.T. Floating Covers* on his tanks at a glance. He may keep close control of supernatant liquor by means of the *P.F.T. Supernatant Selectors and Gauge Glass* located just below the indicators.

Ample space is provided in the control room for convenience in operation of the digester system.

The gas-fired *P.F.T. Heater and Heat Exchanger* (at left) has a capacity of 750,000 Btu per hour. The other unit (at right) is gas and oil fired with a 500,000 Btu per hour capacity. The entire plant incorporates the latest thinking in plant and control room design.

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Complete information on all or part of Levittown's equipment is yours upon request.

Design of plant by | *Albright & Friel, Inc., Philadelphia, Pa.*

Outside view of the four 55-foot digesters showing the convenient position of the control room.

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SEWAGE AND INDUSTRIAL WASTES

Journal of the Federation of Sewage and Industrial Wastes Associations

Volume 26 **December, 1954** **Number 12**

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Separate sludge digestion plant for 4.0 mgd (Imp.) includes two Dorr 60 ft. Clarifiers in foreground, Dorrco Bar Screen and Detritor, Dorr Digester.

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Kitchener, Ontario, Clarifier Repair Parts Costs Record

No. of Units	Size & Type of Clarifiers	Years of Operation	Repair Parts Cost Total	Repair Parts Cost Per Unit	Repair Parts Cost Per Unit Per Year	Repairs as % of Original Cost	Repairs as % of Original Cost Per Year
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Sewage Works

BIOCATALYSTS IN SLUDGE DIGESTION

By Werner N. Grune and Robert Q. Sload

Associate Professor and Research Assistant, respectively, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Ga.

It has become axiomatic in sewage treatment that nothing final has been accomplished until or unless proper disposition is made of the sludge produced. In 1927 Besselievre (1) observed that although the matter of procuring stabilization of the liquid portion of sewage was relatively simple, the element of most trouble has been the resultant sludge and that "In practically every instance where a sewage plant has been a source of nuisance or complaint, the trouble has been found in that unit of the plant wherein the sludge was collected." This quotation points out that the problems involved in the collection and disposal of sludge, although seriously attacked by many excellent investigations with many inroads made toward the eventual and full understanding of this "bugbear" of sewage treatment, are still extant a quarter of a century later and still deserving of further research and evaluation.

Various claims have been made regarding the beneficial effects caused by the addition of bacterial cultures, either as pure strains or in mixtures, and/or the addition of enzyme systems to enhance the digestion of sewage sludge. As early as 1932 Rudolfs (2) reported some experiments in which pure enzymes were added to fresh solids, fine screenings, and activated sludge. The combined results from both laboratory and semi-plant-scale operations showed little improvement in gas production, destruction of volatile matter, drainability, and odors as a result of using the enzymes. More recently, Enzymatic (3) has been described as promoting the reduction of solids and the B.O.D. of sewage, as well as other benefits.

At Houston, Tex., Bryan (4) claims that Bionetic, another biological preparation, added to overloaded digestion tanks resulted in great improvements in the quality of supernatant liquor by reducing the B.O.D. and the suspended solids and by raising the pH.

More recently Heukelekian (5) and McKinney (6) have discussed the theoretical and practical considerations which are expected to result from the addition of pure bacterial cultures and specific enzymes, as well as those resulting from commercial preparations. Heukelekian (5) found that the addition of enzyme and bacterial preparations did not increase the liquefaction of non-sterile fresh sewage solids as measured by the B.O.D. of the supernatant liquor. McKinney (7) discussed some of the theoretical aspects of the biochemistry of anaerobic digestion with the specific purpose of evaluating the effects that the addition of hydrolytic enzymes might have, and reached the inevitable conclusion that if the plant design is such that the biological system can function properly and is operated accordingly, maximum efficiency without the feed of additional organic catalysts will obtain.

In 1938 Chamberlin (8) had demonstrated that the quantities of lipase, diatase, and pepsin are closely allied to gas production and that enzymes play

an important role in sludge digestion. However, sufficient enzymes are produced during digestion so that the addition of different enzymes and groups of enzymes does not increase the rate of digestion. Increased liquefaction resulted from the addition of certain enzymes under very selective conditions, as again demonstrated more recently by Heukelekian (5), while others cause swelling of solids, affecting dewatering later on. In his researches on the effect of biocatalysts on activated sludge, McKinney (6) found that biocatalysts did not speed up the time required to reach biochemical equilibrium in a new activated sludge system, that they did not increase the rate of B.O.D. removal after equilibrium had been reached, that the nature of the biological sludge remained unaffected, and that the use of biocatalysts cannot according to biological principles boost the efficiency of a properly designed and operated activated sludge plant.

The purpose of this paper is to present experimental evidence of the value of one of the biological preparations said to consist of a group of preserved living cultures of anaerobic organisms together with enzyme systems on the digestion of sewage solids. The investigations were undertaken to find out if the addition of this biocatalyst had any effect on the rate at which anaerobic digestion proceeds and on the total gas production. Specifically, the following criteria were set out to be studied:

1. The efficiency of gas production in cubic feet per pound of volatile matter destroyed and the percentage reduction of volatile matter.

2. The onset of methane fermentation as demonstrated by gas production.

3. The comparison of rates at which biological equilibrium is established.

Experiments were conducted by adding the biocatalyst to mixtures of varied proportions of raw and digested sludge. The principal measures for comparison were gas production and volatile matter reduction. Regardless of the content of the biocatalyst, specific types of organisms, and enzyme systems, there undoubtedly exists some proteinaceous matter which is simultaneously added. If the function of biocatalysts is to effect an acceleration in the form of an earlier and/or higher rate of gas production and increased volatile matter reduction over a similarly prepared seeded mixture without the biological preparation, this protein-feed must be considered. Therefore, in about one-half of the experimental runs the equivalent amounts of protein were fed to the corresponding controls to detect any real effects due to the sole addition of bacteria and enzyme groups.

Although most of the digestion experiments were carried out at constant temperatures of 30° and 40°C., a limited number were conducted at 4° and 7°C. Some of the pertinent physical data are given in Table I. The average ratio of sidewall depth to diameter for separate digesters in seven U. S. cities (9) was cited as 0.32 as compared to the values in Table I.

TABLE I.—Summary of Laboratory Test Runs

Run	Incub. Time (days)	Incubation Temperature (° C.)	Digester Capacity (ml.)	Depth-Diam. Ratio[1]	Gas Coll. Capacity (ml.)	Sludge Sample (ml.)
I	61	30	980	0.49	500	250
II	65	30	980	0.49	500	300
III	55	30, 40	2,600	0.56	500	600
IV	37	4, 30, 40	2,600	0.56	2,500	1,000
V	40	7, 30, 40	2,600	0.56	2,500	700

[1] Ratio of sidewall depth to diameter of digester.

The laboratory digesters were, therefore, relatively deeper than the existing prototype. In practice the maximum depth must be limited, since with greater depths the sludge gas is released at the surface in greater volumes and thus tends to cause agitation at the surface and perhaps foaming. The experimental conditions approach those that would prevail in separate sludge digestion tanks that received fresh material only at the start of the period allowed for digestion. It was, however, considered a valid test for these investigations, because it is quite feasible that any effect due to the biocatalyst would be more pronounced in the absence of dilution and reduced dispersion as usually encountered in practice.

It is fully recognized that these experimental investigations under substantial control differ from the conditions found in practice. Discussion of the results hinges on experimental studies and is therefore subject to the limitations of experiment. However, this is a method by which general principles may become established and foundations laid for tests under practical working conditions.

Experimental Technique

The fresh and digested sewage solids were obtained from the primary sedimentation basins and secondary digesters of the Clayton sewage treatment plant, Atlanta, Ga. This primary treatment plant receives domestic sewage with no industrial wastes of any consequence and treats approximately 40 m.g.d.

The sludge mixtures were prepared in the laboratory as soon as possible after collection at the plant, the proportions of raw to digested solids being based on their volatile matter content. Experimentation was initially performed with 250 to 600 ml. of sample in digesters of almost 1,000-ml. capacity and with gas collection apparatus as shown in Table I. Initially the entire equipment was housed in one incubator; therefore, only one temperature could be selected for each run. The incubation temperatures were chosen as closely as is practical to optimum mesophilic environment, which various investigators (10)(11)(12) have reported to extend from 27° to 37°C. However, the evaluation of a biocatalyst should include other temperatures as may be occasioned in plant operation; therefore, both lower and higher incubation temperatures were engaged. A complete schedule of all runs and how they were treated is shown in Table II.

To reduce one of the sources of experimental error, 1 ml. of phosphoric acid was added to the water in each gasometer, most of the gases of decomposition being partially soluble in water.

In Run II, the sludge mixtures varied and biocatalyst was added to digesters No. 3 and 5. The corresponding controls, No. 2 and 4, had the identical sewage substrate. The sludge mixture was a 1:1 ratio of raw to digested sludge, except in digesters No. 2 and 3, where the ratio was 2:1. In none of the runs was there any attempt made to evaluate the effect of the biocatalyst on fresh solids alone, since the purpose of the work herein reported was to evaluate the effects of the addition of certain materials to the sludge as would be encountered in digester and septic tank operation. Furthermore, Heukelekian (5) obtained some results with unsterilized fresh solids which showed no significant increase in the B.O.D. of the supernatant after 18-hr. contact. The concentration of biocatalyst, added as 1.0 g. on every even day of the run up to the 30th day (Table II), amounted to about 53,300 p.p.m. at the end of the period, based on the original sludge volume. This concentration was well above that specified by the manufacturer, but as other investigators have found, the

specified dosage is impractical to achieve on a laboratory scale.

The digesters for Run III and all subsequent runs were immersed in individual constant-temperature tanks. Each tank held a pair of digesters of identical sludge mixture and the digesters were exposed to identical temperature deviations. To one digester the biocatalyst was added while the other served as the control. In Run III, digesters No. 1 and 2 were kept at 40° C, the others at 30° C. All digesters received the same sludge mixture based on the ratio of 1:1 of fresh to digested solids and biocatalyst was added to digesters No. 2, 4, and 6. To bring the amount of biocatalyst closer to the recommended level, only 0.5 g. was fed on all even days of the run. The resultant concentration was about 20,000 p.p.m. in each batch digester by the 48th day, after which the feeding was stopped.

Beginning with Run IV, the intensity of the investigations was increased to 14 digesters simultaneously incubated with sludge volumes raised to 1,000 ml. each. Various sludge mixtures of the ratio of 1:1, 1.5:1 and 2:1 of fresh solids to digested solids, and constant incubation temperatures of 40°, 30°, and 4° C. were employed (Table II). Because of the extremely low rate of digestion in poorly heated digesters during the coldest winter

TABLE II.—Experimental Conditions, Gas Production, and Volatile Matter Reduction

Run	Digester No.	Experimental Conditions					Total Gas Production[r]		Vol. Matter Reduction (%)
		Sludge Mixture[a]	Incub. Temp. (° C.)[b]	Incub. Period (days)	Feed[c]	Conc. of Biocatalyst (p.p.m.)	(cc./g. V.M.)	(cu. ft./ lb. V.M.)[d]	
I	1	1:1	30	61	None	[e]None	105	8.1	23
	2	1:1	30		None		112	15.3	14
	3	1:1	30		None		103	16.6	13
	4	1:1	30		None		110	33.0	5
	5	1:1	30		None		103	26.2	7
II	1	[f]1:1	30	65	None	53,300	[g]362	24.7	25
	2	2:1	30		None		[g]647	17.2	69
	3	2:1	30		[h]B		[g]182	8.5	38
	4	1:1	30		None		[g]498	12.4	71
	5	1:1	30		[h]B		[g]516	15.7	58
III	1	1:1	40	55	None	20,000	[i]309	6.8	80
	2	1:1	40		[j]B		[i]307	5.8	91
	3	1:1	30		None		[i]230	5.1	76
	4	1:1	30		[j]B		[i]486	15.6	53
	5	1:1	30		None		[i]338	9.0	67
	6	1:1	30		[j]B		[i]476	15.8	53
IV	1	1:1	40	37	[k]Pr	5,400	457	14.2	53
	2	1:1	40		[k]B		442	15.4	46
	3	1:1	30		[k]Pr		410	18.0	36
	4	1:1	30		[k]B		419	15.2	43
	5	1.5:1	30		[k]Pr		[m]327	[m]—	—[m]
	6	1.5:1	30		[k]B		528	26.5	39
	7	1.5:1	40		[k]Pr		550	31.8	36
	8	1.5:1	40		[k]B		520	19.2	52
	9	2:1	30		[k]Pr		413	12.2	55
	10	2:1	30		[k]B		431	9.6	73
	11	1.5:1	30		None		495	13.5	67
	12	1.5:1	30		[n]F		490	16.0	57
	13	1:1	4	44	[k]B	—	—	—	—
	14	1:1	4	44	[k]Pr	—	—	—	—

TABLE II.—*Continued*

Run	Digester No.	Experimental Conditions					Total Gas Production[r]		Vol. Matter Reduction (%)
		Sludge Mixture[a]	Incub. Temp. (° C.)[b]	Incub. Period (days)	Feed[c]	Conc. of Biocatalyst (p.p.m.)	(cc./g. V.M.)	(cu. ft./lb. V.M.)[d]	
V	1	1:1	40	40	[k]Pr	6,400	486	17.4	3.5
	2	1:1	40		[k]B		397	9.3	7
	3	1:1	30		[k]Pr		476	15.2	40
	4	1:1	30		[k]B		481	24.2	3
	5	1.5:1	30		[k]Pr		268	21.6	27
	6	1.5:1	30		[k]B		340	17.8	29
	7	1.5:1	40		[k]Pr		420	13.5	50
	8	1.5:1	40		[k]B		430	13.1	51
	9	2:1	30		[k]Pr		168	4.9	17
	10	2:1	30		[k]B		156	4.2	41
	11	1.5:1	30		[o]Pr		319	15.3	33
	12	1.5:1	30		[n]F, B[o]		321	13.5	38
	13	0.78:1	7		[q]B	—	—	—	—
	14	0.78:1	7		[q]Pr	—	—	—	—

[a] Ratio of raw to digested sludge, based on weight of volatile matter.
[b] 40° temp. ±1.0°, all other ±0.5° C.
[c] Pr = protein substrate, B = biocatalyst, F = fluoride.
[d] Cubic feet of gas produced per pound of volatile matter destroyed.
[e] Calibration experiment.
[f] Seed = digested sludge of Run I.
[g] Gas production based on 58 days.
[h] 1 g. added on all even days.
[i] Gas production based on 51 days.
[j] 0.5 g. added on all even days.
[k] 0.3 g. added on all odd days.
[m] Digester broke after 15th day.
[n] 4.55 p.p.m. F (as NaF) added on first day only.
[o] 0.3 g. added on fifth day only.
[p] 4.55 p.p.m. F (as NaF) added on first day only; 0.3 g. biocatalyst added on fifth day only.
[q] 0.3 g. added on days 12, 16, 18, 22, 24, 26, 28, and 30.
[r] Under standard conditions.

months and under arctic conditions, it was considered of interest to explore the value of a biocatalyst in the cryophilic temperature zone.

Also starting with this run, the digesters serving as controls received concentrations of proteinaceous matter residue equivalent to that contained by the biocatalyst. This proteinaceous material was extracted by preparing a slurry of the biocatalyst with distilled water. The slurry was brought to a constant temperature of 100° C. and held there for about 2 hr. It can be safely assumed that bacteria, microorganisms, and enzyme systems could not survive such treatment and that the residue simply represents the protein mass plus inert materials. This residue, repulverized, is referred to as Pr in Table II.

Since some of the results of Run III tended to indicate certain effects in the presence of the biocatalyst, it was deemed necessary to establish a more valid control to which the equivalent amount of protein was added. By this approach a more accurate analysis of specific effects due to possible increased beneficial organisms and enzyme systems, over and above the protein added to the sample, would then be possible.

In a further effort to reduce the biocatalyst concentration, the feed for Run IV was set at 0.3 g. on all odd days for the duration of the run, amounting to approximately 5,400 p.p.m. based on the original sludge.

Biocatalyst and protein were added during this entire run of 37 days.

Run V was performed in the same manner as Run IV for digesters 1–10. The concentration of biocatalyst and protein were 6,430 p.p.m. each on the 30th day, after which the feeding was stopped. Digesters No. 11 and 12 served primarily to evaluate any effects due to the fluoride ion as in Run IV and are to be discussed in a subsequent paper, but also received 0.3 g. of protein and biocatalyst on the 5th day only. The purpose was to observe any effect due to biocatalyst after an initial period of acid digestion. Digesters No. 5 and 6 were of the identical sludge mixture held at the same temperature as were No. 11 and 12, the difference being that protein and biocatalyst were added to No. 5 and 6 every other day. Therefore, comparing No. 11 and 12 with No. 5 and 6 may show whether the addition of the preparation after the onset of digestion and after an equilibrium is established would produce any beneficial results.

Digesters No. 13 and 14, held at 3° C., were carried over from Run IV. The gas production during Run IV had been small, as expected, and there appeared to be no significant effect due to the biocatalyst. From the end of Run IV to the beginning of Run V, a period covering 110 days, there were no further material changes in gas production or pH. Beginning with Run V, 300 ml. of the supernatant were drawn off each digester and the volume replaced by 300 ml. ripe sewage solids, the same seed as was used for all of Run V, to observe if gasification would resume. The temperature was set initially at 10° C., but after 24 hr. was reduced to 7° C. and maintained there for 40 more days. Active gasification became re-established after 3 days and readings were continued for an additional 37 days. On the 12th day, after an apparently new equilibrium was reached as indicated by a rising pH, feeding of biocatalyst and protein to digesters No. 13 and 14 was resumed. The total concentration of biocatalyst and protein added to digesters No. 13 and 14, respectively, during Run IV amounted to 6,600 p.p.m., and 3,000 p.p.m. more were added during Run V to whatever concentration had remained. The data obtained from the

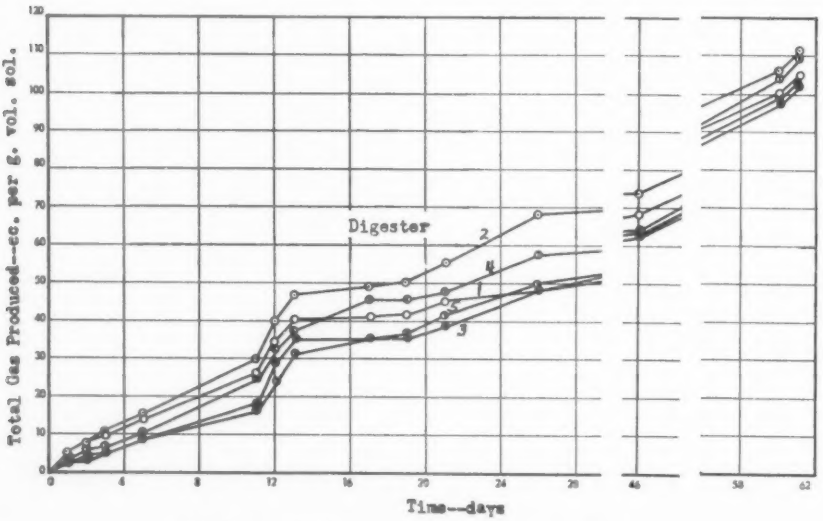

FIGURE 1.—Cumulative gas production, Run I.

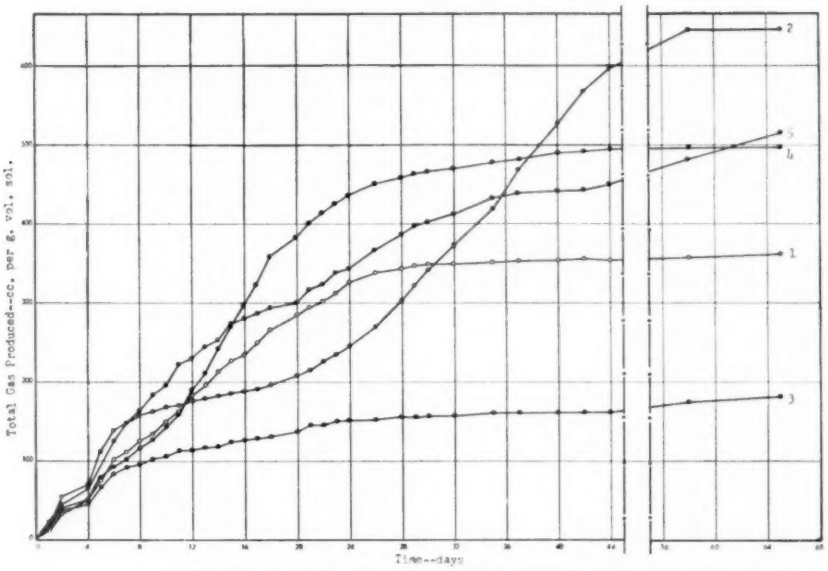

FIGURE 2.—Cumulative gas production, Run II.

cold digesters covers a total digestion period of more than 190 days.

Experimental Results

For purposes of comparison all observed gas volumes were reduced to standard conditions.* Volatile solids, determined in accordance with Standard Methods (13), were assumed to represent the organic matter, as is common practice.

Cumulative Gas Production

Cumulative gas production curves for Runs I through V are given in Figures 1–5.

Run I served as the calibration experiment and showed that the variation in cumulative gas production after 61 days between any two digesters did not exceed 8 per cent. Since this experimental error was well within the expected variations, both techniques and laboratory equipment were considered sufficiently consistent to proceed with the study.

* Volumes at 0° C. (273° K.) and 760 mm. (29.92 in. Hg.)

The total cumulative gas volumes obtained from Run II vary considerably from each other. Digester No. 1 may be disregarded in any comparison, because it contained a singular, poorly seeded mixture.

It is of interest that both digesters with 53,300 p.p.m. of biocatalyst show far less cumulative gas production up to 58 days of measurement than their respective controls. However, digester No. 5 outproduced digester No. 4 (control) for the first 15 days, which may be considered as a beneficial effect caused by the biocatalyst during the onset of active decomposition. The final gas production values for all five runs are given in Table II. It may be assumed that some inhibiting influence caused digester No. 3 to lag behind No. 4. It would seem that there was no beneficial effect exerted by the biocatalyst under the more or less heavily loaded conditions of fresh to digested solids.

Run III represents a set of data with only a 1:1 ratio of fresh to ripe sludge mixture. Only the temperature

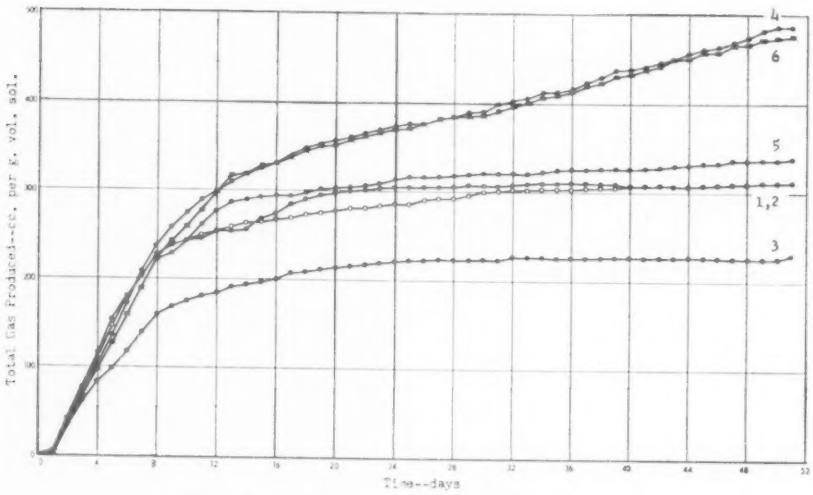

FIGURE 3.—Cumulative gas production, Run III.

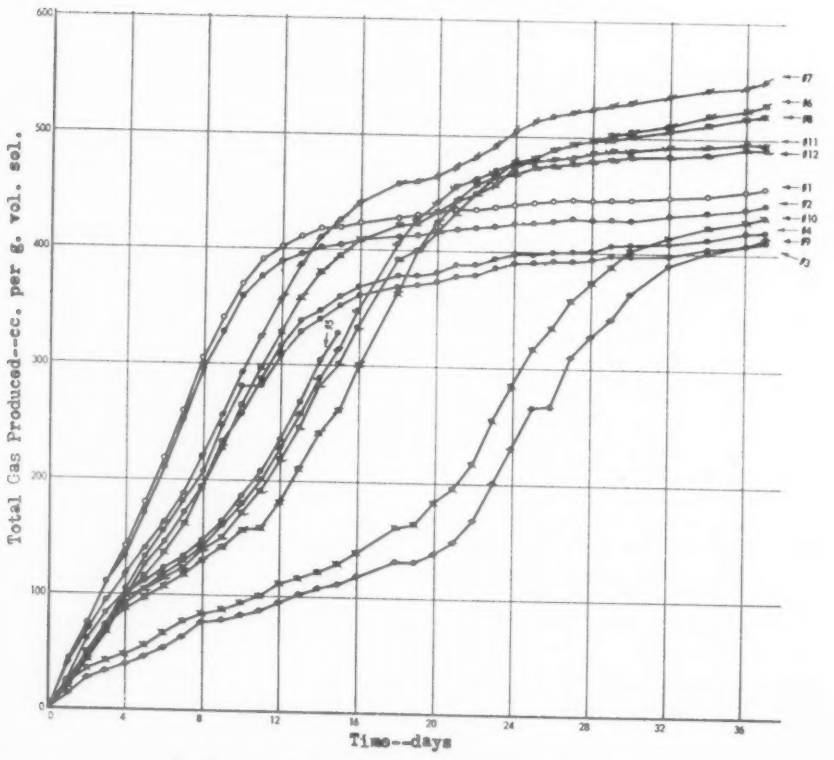

FIGURE 4.—Cumulative gas production, Run IV.

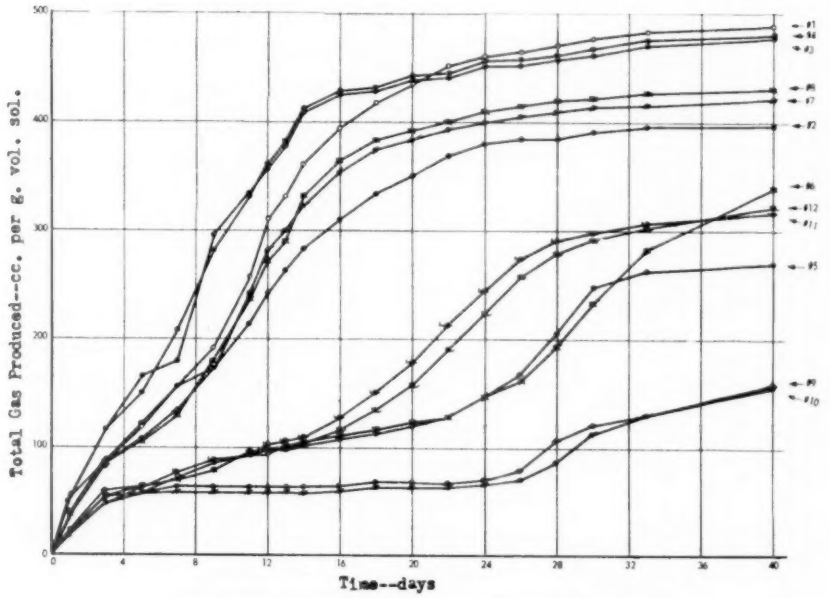

FIGURE 5.—Cumulative gas production, Run V.

was varied. Comparing digesters No. 1 and No. 2, there appears no significant difference at 40° C. in the presence of 20,000 p.p.m. of biocatalyst. At the 30° C. temperature digester No. 3, the control, shows less gas production than digester No. 4. A similar relationship appears for digesters No. 5 and No. 6. Digesters No. 3 through No. 6 were started with the same sludge mixture and held at 30° C. From Figure 3 a beneficial effect due to the biocatalyst may be concluded, which could have resulted from the proteinaceous material in the biocatalyst.

In Run IV, the digesters incubated at 40° C. with 5,400 p.p.m. of biocatalyst showed less total gas production than their respective controls, containing the equivalent amount of protein. There were no significant differences between digesters at 30° C. Comparing No. 5 with No. 6, the 15th day reading must be used, because digester No. 5 broke. Digester No. 11 had the same sludge mixture as No. 5 and therefore also serves as a control to No. 6.

Run V shows that digester No. 2, at 40° C. and with 6,400 p.p.m. of biocatalyst added, produced approximately 20 per cent less total gas than the control after 40 days. Slightly increased gas production in the presence of the biocatalyst may be noted for the other digester pair at 40° C.

A comparison of the digesters with 1:1 and 2:1 mixtures at 30° C. showed no significant difference with the biocatalyst.

The 1.5:1 mixtures at 30° C. exhibited 27 per cent greater gas production with the biocatalyst during the methane fermentation stage comparing No. 5 with No. 6, whereas the difference between digesters No. 11 and No. 12 was insignificant.

Daily Gas Production

A typical plot of the daily rates of gas production for Run V is shown in Figure 6, the rate being expressed as cubic centimeters per gram of fresh

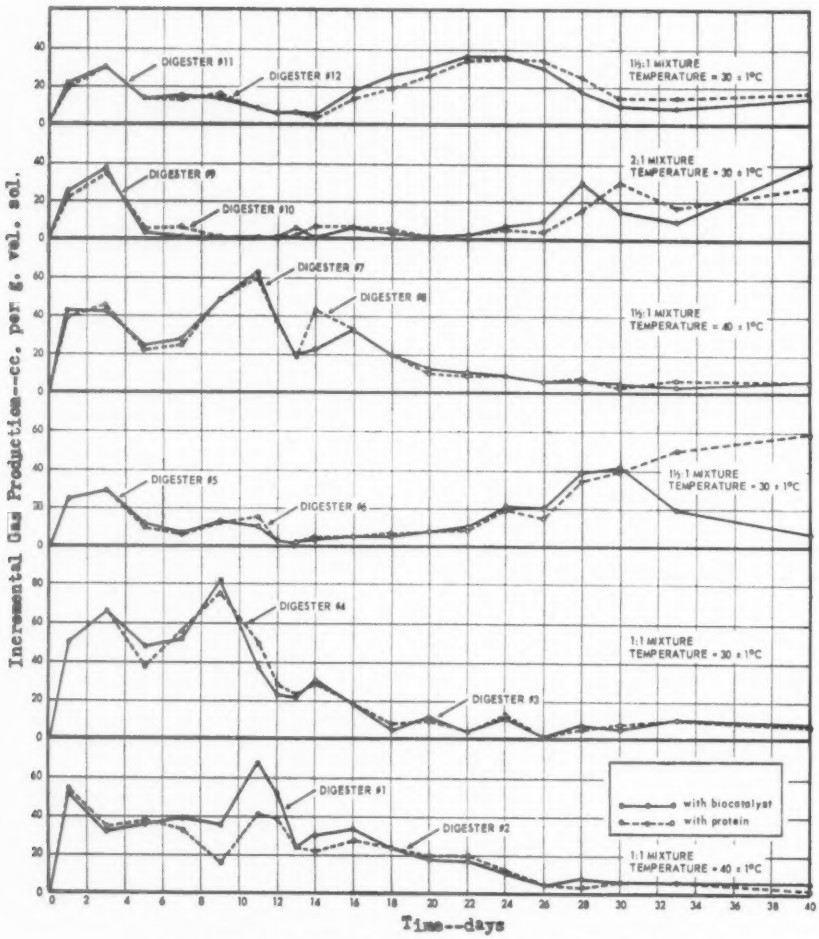

FIGURE 6.—Daily rates of gas production, Run V.

organic solids. A comparison of daily gas production volumes did not affect the results already obtained from the cumulative gas curves presented.

Reaction Velocity Constant

Reaction velocity constants were computed for all the runs as an additional basis for comparison.

It is more difficult to obtain sufficient data for the purpose of computing a velocity constant for anaerobic digestion than for aerobic digestion. The number of days of observation necessary to fit a representative unimolecular type of curve is increased and the interpretation of where acid digestion ends and methane fermentation begins is often poorly defined. The usual value of k (base 10) for anaerobic digestion is from 0.02 to 0.04 at 20° C. Phelps (14) describes the rate as about 10 per cent, or a k-value of 0.046, at 24° C.

The composite reactions involved in the stabilization of the complex organic matter in well-seeded sludge may be assumed to follow the first-order re-

action in a general way, expressed as:

$$y = L(1 - 10^{-kt}) \quad \ldots\ldots (1)$$

where y is the amount of gas produced (in ml.), in time t (days), and k is the reaction velocity constant. Eq. 1 provides a fairly good fit to the observed cumulative gas volume during the active acid digestion phase. If the methane fermentation stage continues

TABLE III.—Computed Values of Reaction Velocity, k (base 10), and Ultimate Gas Production, L (cc. per g. Vol. Sol.)

Run	Dig. No.	[a] k_1	[b] k_2	[c] k_{lag}	L_1	L_2	L_{lag}
I	1	0.089	0.043	—	312	994	—
	2	0.064	0.062	—	413	1,091	—
	3	0.031	0.049	—	500	941	—
	4	0.005	0.051	—	302	950	—
	5	0.098	0.061	—	214	883	—
II	1	0.023	—	—	4,116	—	—
	2	0.083	0.0002	—	1,791	29,546	—
	[d] 3	0.051	—	—	1,408	—	—
	4	0.016	—	—	7,873	—	—
	[d] 5	0.023	—	—	5,790	—	—
III	1	0.034	—	—	9,202	—	—
	[d] 2	0.058	—	—	8,489	—	—
	3	0.056	—	—	6,264	—	—
	[d] 4	0.032	—	—	12,910	—	—
	5	0.049	—	—	9,191	—	—
	[d] 6	0.031	—	—	12,812	—	—
IV	1	0.048	—	—	21,505	—	—
	[d] 2	0.048	—	—	20,409	—	—
	3	0.037	—	—	19,583	—	—
	[d] 4	0.034	—	—	20,450	—	—
	5	0.095	—	—	6,848	—	—
	[d] 6	0.087	—	—	6,217	—	—
	7	0.025	—	—	25,562	—	—
	[d] 8	0.024	—	—	24,551	—	—
	9	0.024	0.020	—	8,849	29,877	—
	[d]10	0.018	0.034	—	12,746	24,179	—
	11	0.017	—	—	26,412	—	—
	[e]12	0.016	—	—	27,081	—	—
V	1	0.073	0.085	0.093	5,083	10,131	10,057
	[d] 2	0.111	0.067	0.066	4,043	8,471	8,485
	3	0.040	—	—	10,935	—	—
	[d] 4	0.038	—	—	11,228	—	—
	5	0.075	0.100	0.051	3,536	8,682	9,776
	[d] 6	0.067	0.021	0.011	3,667	17,241	26,348
	7	0.148	0.066	0.071	4,167	12,680	12,593
	[d] 8	0.146	0.064	0.067	4,104	13,152	13,068
	9	—	—	0.096	—	—	3,504
	[d]10	—	—	0.090	—	—	3,815
	11	0.063	0.034	0.036	3,829	11,241	11,040
	[f]12	0.066	0.021	0.039	3,558	13,748	11,100

[a] k_1 values for acid digestion stage only.
[b] k_2 values for methane fermentation stage only.
[c] k_{lag} values starting with y after lag period.
[d] Biocatalyst added.
[e] NaF added.
[f] NaF added and biocatalyst added on 5th day only.

without any apparent transitional period, then the unimolecular equation holds for the entire accumulated gas curve. The point $y = 0$ when $t = 0$ is used in this case as a valid point for the curve fitting.

Table III gives the values of k (base 10) computed from the initial day to the last day on which gas production was observed, in accordance with the slope method (14)(15).

If there exists a marked transition, the second stage may be represented by a unimolecular type curve with the properly fitted lag period, as suggested by Thomas (15):

$$y = L[1 - 10^{-k(t-t_0)}] \quad \ldots\ldots(2)$$

in which t_0 is the lag period. In fitting a curve of this type to the data, the origin is not used as an experimental point. As shown in Table III, k-values for all cumulative gas curves were obtained. Since the curves of Run I showed a distinct change in slope on about the 11th day, k_1 is the value of the velocity constant through the 11th day and k_2 is the velocity constant from the 11th day to the end of the observation period, which in this case is the 60th day. The same procedure was used to compute k-values for Runs II, III, and IV, k_2 only being calculated wherever a definite break appeared in the slope of the cumulative gas curve. In Run V the average slope of the gas curve was extremely small for digesters No. 9 and No. 10, therefore no reasonable k_1-value could be computed. The k_2-values, as far as available for Run V, are shown in Table III. Another set of k-values, referred to as k_{lag}-values, was computed from the data by continuing the slope of the curve backwards in time from the transition point and abstracting a new origin, representing lag periods of from 4 to 22 days and then using Eq. 2.

The results of statistical evaluation of the significance of any beneficial effects due to the addition of biocatalyst in concentrations from 5,000 to 50,000 p.p.m. for various mixtures and temperatures is shown in Table IV. The means for comparison in this table is the reaction velocity constant.

TABLE IV.—Average Differences and the Probability, P, of k-value Occurrences by Chance Alone

Basis for Comparison	No. of Runs	Values of k*	
		$\bar{d} = \frac{\Sigma(k_c - k_b)}{n}$	P (%)
k_1 values only	16	+0.0021	63
k_2 values only	5	+0.0197	29
k_{lag} values only	5	+0.0191	18

* k_c = control; k_b = with biocatalyst.

Table IV shows no significant difference, and therefore no significant effect, due to the biocatalyst on the reaction rate of anaerobic digestion from the data obtained in these experiments. Further analyses of comparing only k-values obtained from the same mixtures, or under the same temperatures, or with the same concentrations were carried out, but without any change in the results. It should be noted that the k-values in the presence of biocatalyst are lower, on the average, than those for the corresponding controls.

Ultimate Gas Produced

The ultimate gas volume, L, for Runs I through V and as computed by the slope method, also are given in Table III. Subscripts for L have the identical meaning as in connection with the k-values. The results of statistical analyses, using the L-values as the basis for comparison, are given in Table V.

Although the L-values are greater in the presence of the biocatalyst, signifying that the total ultimate gas production would be greater on the average, this difference again is not significant. Table V shows that 37, 74, and 78 per cent of the time the average difference of the L-values between control and sample can be expected to be as great as 564, 836, and

TABLE V.—Average Differences and the Probability, P, of L-Value Occurrences by Chance Alone

Basis for Comparison	No. of Runs	Values of L	
		$\bar{d} = \frac{\Sigma(L_c - L_b)}{n}$	P (%)
L_1 values only	15	− 564	37
L_2 values only	5	− 836	74
L_{lag} values only	5	−3,169	78

3,169 ml., for 15, 5, and 5 runs, respectively, due to chance factors alone.

Reduction of Volatile Matters

Besides daily gas production measurements, initial and final solids, and volatile matter contents were determined for each digester. From these data the reduction of volatile matter during the period of digestion was calculated. Gas yield, in cubic feet of total gas per pound of volatile matter destroyed, is given in Table II.

Comparing gas yield for all 16 digesters with biocatalyst *vs.* the corresponding controls, in 50 per cent of the cases there is a higher and in 50 per cent of the cases there is a lower yield.

Considering the 1:1 mixtures only, five digesters out of a total of eight at 30° C. and 40° C. showed more gas produced per pound of volatile matter destroyed in the presence of biocatalyst. If there is any greater gas yield with the biocatalyst it seems to be operative at 30° C. (4 out of 5 cases) rather than at 40° C. (only 1 out of 3 cases). Considering only those runs in which the equivalent amount of proteinaceous material was added to the controls, the average gas yield is found to be 16.1, compared with 16.2 cu. ft. per pound of volatile matter destroyed for the controls.

Examining the results with the 1.5:1 mixtures, only one digester out of a total of five at 30° C. and 40° C. exhibited a greater gas yield in the presence of biocatalyst. In four cases (two at 30° C. and two at 40° C.) where the yield in the presence of biocatalyst is lower, the difference is 15.8, as compared with 23.0 cu. ft. per pound of volatile matter destroyed with protein added to all controls.

In all cases of 2:1 mixtures tested, there was less gas yield in the presence of the biocatalyst. A comparison shows an average specific gas production of 7.4 *vs.* 11.4 cu. ft. per pound of volatile matter destroyed. Therefore, the poorest seeded mixtures showed decreased gasification rather than any increase. This reduced gas yield with concentrations of biocatalyst may be due to an increased liquefaction of sewage solids.

The reduction of volatile matter, expressed as per cent volatile matter reduction, also is given in Table II. Analyzing all the data between the sample with biocatalyst and the corresponding controls shows that in 7 cases the percentage reduction was

TABLE VI.—Gas Yield and percentage Volatile Matter Reduced

Type of Experiment	Number of Compared Experiments	Gas Yield (cu. ft./lb. V.M.)		V.M. Reduction (%)	
		With Biocat.	Without Biocat.	With Biocat.	Without Biocat.
Av. values from all experiments	16	14.3	14.3	44.7	45.9
Av. values from experiments with no protein added to control	5	12.2	10.1	58.6	72.6
Av. values only from experiments with protein added to control	11	15.3	16.2	38.3	38.1

lower and in 9 cases the percentage reduction was higher in the presence of the biocatalyst.

Comparing only those runs with equivalent protein added to the controls, in 8 cases out of 11 the percentage reduction is higher and in 3 cases the percentage reduction is lower between sample *vs.* control.

A complete summary of the results pertaining to volatile matter reduction is given in Table VI.

pH

Prior to Run IV only litmus paper was used to indicate the pH. Beginning with Run IV a separate bottle for pH measurements was maintained under the same conditions as each pair of digesters and containing the identical substrate. A daily sample was measured on a Beckmann pH meter and returned. Since no biocatalyst or protein was added to the sample bottle, the pH readings supply only information on the progress of digestion of the substrate. These pH measurements are summarized in Figures 7 and 8.

During Run IV alkaline fermentation became established in digesters No. 1 through No. 8 at from 4 to 6 days, in digesters No. 9 through No. 12 after 10 days. In digesters No. 13 and No. 14, the cold temperature study, the pH after first falling to 5.0 went to 7.0 on the third day and stayed close to 7.0 until the 16th day. Unfortunately, the pH meter went out of order after the 16th day and readings could not be resumed until Run V.

During Run V, the alkaline fermentation stage was not reached by any of the mixtures at any temperature prior to the 12th day according to the pH. The sludge in digesters No. 9 and No. 10 exhibited a lag period of 30 days to reach a pH value above 7.0. This de-

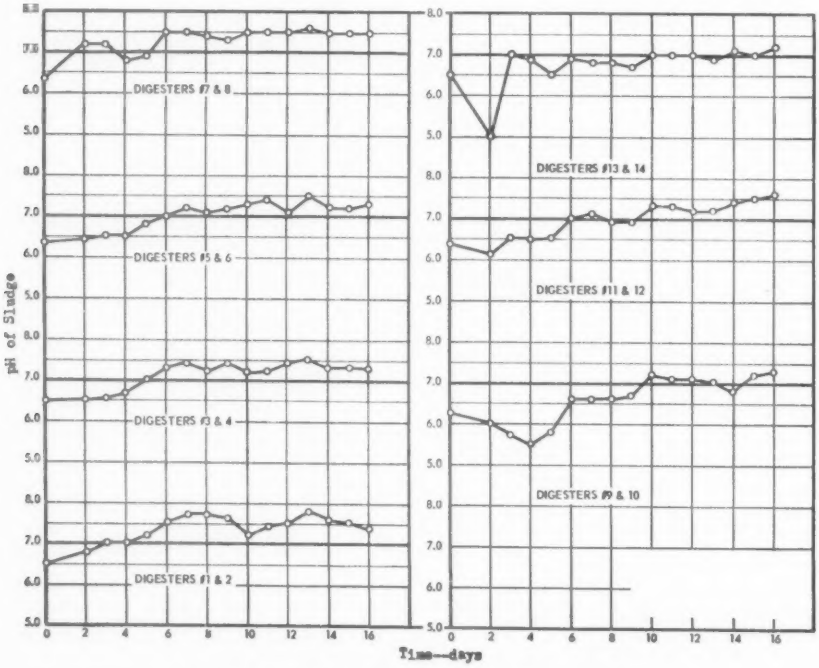

FIGURE 7.—Variations in pH of sludge, Run IV.

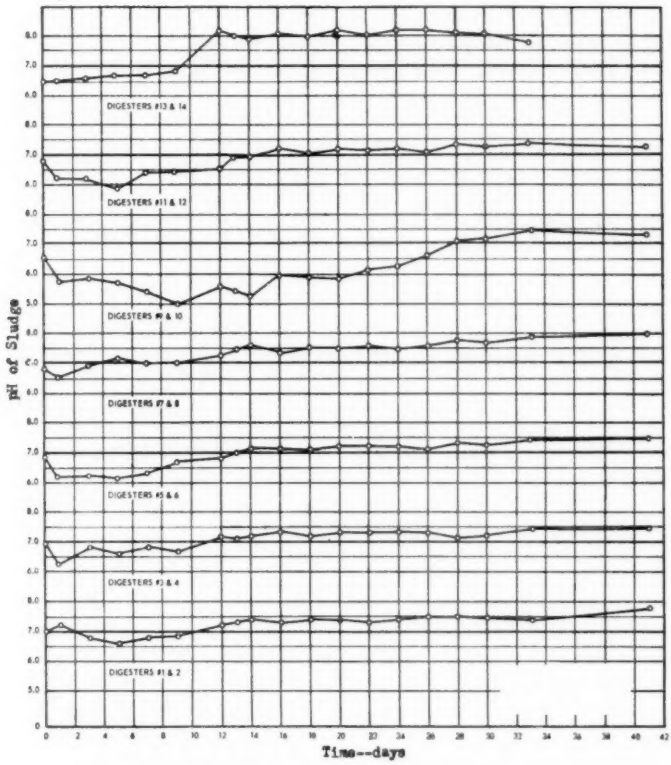

FIGURE 8.—Variations in pH of sludge, Run V.

lay was also clearly demonstrated by the cumulative gas curve (Figure 5), where active gasification did not start until about the 28th day. The sludge mixture in digesters No. 11 and No. 12 lagged until the 16th day before any alkaline pH became established, which is again corroborated by the gas curves. In the cold temperature study, digesters No. 13 and No. 14 exhibited an alkaline pH by the 12th day, after reseeding at the beginning of Run V and produced the desired results of renewed active gas production.

Cold Temperature Studies

The laboratory procedure for digesters No. 13 and No. 14, held at 3° C. for 154 days, then raised to and maintained at 7° C. for an additional 41 days, has been previously described. The original fresh solids to digested sludge mixture was 1:1 by weight, based on the volatile matter content. The progress of digestion in terms of cumulative gas production is shown in Figure 9. Digester No. 13 received a total concentration of 6,600 p.p.m. of biocatalyst in 44 days. Digester No. 14 received the analagous protein feed.

The cumulative gas curves show that digester No. 14 produced more gas than No. 13, containing the biocatalyst, over the 44-day period. The actual difference is 7.7 cc. per gram of volatile solids, compared to only 4.8 cc., gas volumes corrected to standard conditions, or 38 per cent less gas in the presence of biocatalyst as compared with the protein-fed control.

Beginning with Run V, on the 154th day of continuous incubation at 3° C., observations were resumed. Since the original sludge mixture had been almost dormant in the interim, with little or no gas produced and no major pH change, almost all of the supernatant was carefully withdrawn without further disturbing the digesters. This volume was replaced with the same seed as used for Run V.

After reseeding and at a temperature during the first 24 hr. of 10° C., the mixture became active once again. The incubation temperature was reduced to 7° C. after the first day and maintained at 7° C. for the duration of Run V. These temperature changes apparently did not deleteriously affect the organisms, for the newly seeded mixture continued to gasify quite vigorously with the pH climbing continuously and reaching the alkaline fermentation stage on the 12th day and maintaining it, as previously pointed out.

The course of renewed gas production is shown in Figure 10. Although digester No. 13, with 6,600 p.p.m. biocatalyst, had lagged behind during Run IV, it now exhibited the same or slightly higher cumulative gas values as compared to digester No. 14. A concentration of 3,000 p.p.m. of biocatalyst and protein above whatever material remained from the previous 6,600 p.p.m. dosage, was added during Run V. Digester No. 14 received the protein. At the end of the 40-day period of Run V it appears that the biocatalyst did not improve cold temperature (3° C.) gasification with the biocatalyst feed initiated at the beginning of the incubation period, nor did it aid in the gas production at 7° C. after reseeding the sludge mixture. It is observed, however, that the almost dormant sludge became active again, with and without biocatalyst, after reseeding. The total gas produced during the last 40 days (Run V) was greater than the volume collected in 44 days during Run IV. The difference in gasification may at least in part be due to the more elevated temperature of 7° C. instead of the 3° C. temperature used earlier.

Summary and Conclusions

This study on the effects of a biocatalyst used in concentrations between 5,400 p.p.m. to 53,300 p.p.m., shows the following:

1. The rate of gas production over similarly prepared seeded mixtures, either with or without equivalent protein, was not significantly altered.

2. The volume of gas production did not increase as a result of the biocatalyst over similarly prepared mixtures, with or without equivalent protein concentrations, during the periods covered by these studies. Comparing the fitted parameter, L, total ultimate

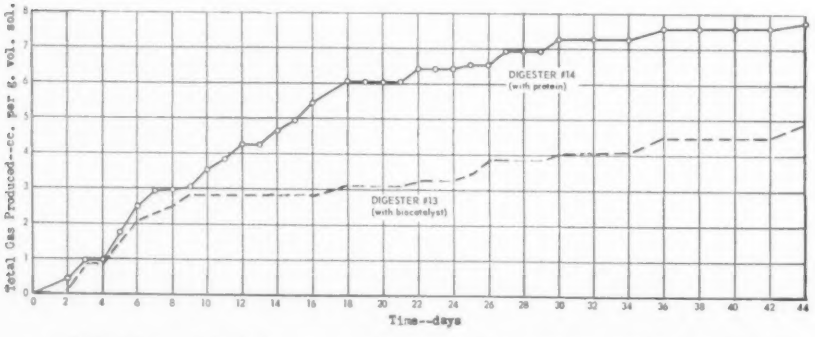

FIGURE 9.—Cumulative gas production, cold temperature study, Run IV.

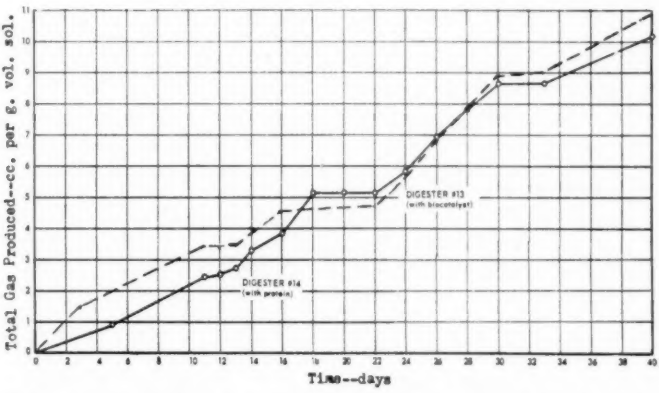

FIGURE 10.—Cumulative gas production, cold temperature study, Run V.

gas production, there appears no significant benefit due to the presence of the biocatalyst.

3. Any beneficial effect on the gas yield (cubic feet per pound of volatile matter destroyed) demonstrated with biocatalyst added to the sample disappeared when the yield was compared to only those controls which were provided with the equivalent concentration of protein.

4. The percentage reduction of volatile solids was less in the presence of biocatalyst compared to those controls without protein. The percentage reduction was found to be the same when the equivalent protein-containing controls were compared.

5. It appears from a review of these experiments that there was less cumulative gas production (cubic centimeters per gram of volatile solids), as well as less gas yield (cubic feet per pound of volatile matter destroyed), at any of the mixtures of fresh to digested solids studied at 40° C. with biocatalyst as compared to the control with the equivalent protein concentration. That an incubation temperature at 40° C. produces less gas than at 30° C. may be expected, but the reduced production in the presence of biocatalyst may have been caused by greater liquefaction, although the latter was not measured in these experiments.

6. The beginning of the active methane-fermentation stage did not appear to be expedited with the biocatalyst present according to the cumulative gas production curves herein presented.

7. The rate at which equilibrium is established did not appear to be affected because no beneficial effects were found due to 4,200 to 6,400 p.p.m. biocatalyst added after an initial period of acid digestion at temperatures of 30° and 7° C.

8. There appeared to be no increased benefits from almost 1 percent of biocatalyst during the cold temperature studies carried out at 3° and 7° C.

9. Although no studies were made on the effect of the biocatalyst on sludge drying characteristics, such benefit was not noted by previous investigators studying specific enzyme additions. The only visual difference of the oven-dried material that may be reported is that the dried sludge containing biocatalyst was usually of darker appearance than the corresponding control without the protein.

It is unlikely that without any material benefits in batch digesters under controlled laboratory conditions and maximum contact there could be any

increased benefits in continuously operating separate digesters, septic tanks, or Imhoff tanks, due to factors of dilution and dispersion, as well as other uncertainties and difficulties, not controllable in plant operation.

Acknowledgments

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ELUTRIATION EXPERIENCE AT THE BAY PARK SEWAGE TREATMENT PLANT *

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In addition to acquainting others with some of the problems that may arise with the use of sludge elutriation, the purpose of this paper is to stimulate further research in the field of this valuable aid to vacuum filtration.

The present facilities at the Bay Park sewage treatment plant are designed to treat 27 m.g.d. and include the activated sludge process, digestion of a mixture of activated and primary sludges, and vacuum filtration. Prior to filtration, the digested sludge is elutriated. Elutriation is simply a process in which water is thoroughly mixed with a sludge and the mixture permitted to undergo sedimentation in order to remove certain constituents, thereby reducing the demand for conditioning chemicals.

The sludge elutriation facilities for this plant were designed on the basis of a 3:1 wash-water ratio and a detention time of 2.5 hr. This detention time is computed from the total sludge-water mixture sent to the elutriation tank and the latter's total volume. When the elutriation system was operated as designed, two difficulties arose. The first was that the high solids in the effluent (elutriate) returned to the wet well caused a high solids recirculating load ranging between 25 and 45 per cent of the total suspended solids load entering the preliminary sedimentation tanks. The second serious difficulty was that the elutriated solids did not concentrate well. The elutriated sludge usually ranged between 2.5 and 3.0 per cent solids, whereas the digested sludge sent to the elutriator contained 3.5 to 4.0 per cent solids. It was noticed that on those occasions when the sludge was permitted to remain in the elutriator for a day or more, its concentration increased to 3.5 per cent. The low solids content of the elutriated sludge increased the amount of coagulant required to condition the sludge and reduced the filter yield when compared with the design anticipations. Both of these factors materially increased the operating costs.

A preliminary study made to determine the cause or causes involved brought certain factors to light, as follows:

1. The dry solids surface loading.
2. The detention time of the solids undergoing compaction.
3. The corrected liquid detention time.
4. The volatile matter content of the sludge.
5. The solids containment in the elutriator.

All but the containment factor directly influence the conditioning chemical demand.

The iron salt required to complete chemical reaction with alkalinity (1) is

$$\% \text{ FeCl}_3 = 1.08 \times \frac{\% \text{ Sludge Moisture}}{\% \text{ Sludge Solids}} \times \frac{\text{p.p.m. Alkalinity}}{10{,}000} \quad (1)$$

The iron salt used for the volatile-solid complex (2) is

$$\% \text{ FeCl}_3 = K_v \times \frac{\% \text{ Volatile Matter}}{\% \text{ Ash}} \quad (2)$$

* Presented at 1954 Spring Meeting, New York Sewage and Industrial Wastes Assn.; Syracuse, N. Y.; June 14–15, 1954.

The sum of Eqs. 1 and 2 is the total per cent ferric chloride on a dry solids basis that is "theoretically" required to condition the sludge for vacuum filtration. K_v, a constant, varies between 1.08 and 3.25; however, data from many plants indicate an average of 1.6. Examination of Eq. 1 reveals the influence that both solids concentration and alkalinity have on the ferric chloride demand. An increase in the solids content would decrease the iron demand. Numerous studies indicate that greater concentration is obtained with greater solids detention. However, a detention time is reached beyond which the additional compaction gained per additional unit of time does not justify the investment required to provide the added facilities needed for longer detention. The limitation of detention time is also dependent upon the settling property and the compactibility of the sludge. A sludge that settles and compacts readily will require a much shorter detention time than one that does not.

Operating experience at the Bay Park plant indicates that its sludge requires an absolute minimum of 12 hr. for fair concentration. Sludge detention of 24 or more hours yields a satisfactory sludge that results in a good filter yield and a reasonable iron demand. Adequate storage space should be provided in the design for the sludge undergoing compaction, with the volume dependent on the type of sludge to be handled.

The alkalinity of the elutriated sludge is dependent on the alkalinity of the sludge to be elutriated, as follows (3):

$$E = \frac{D - RW}{R - 1} \qquad (3a)$$

Also, the ratio of the wash water is

$$R = \frac{D - E}{E - W} \qquad (3b)$$

in which

E = alkalinity of the elutriated sludge, p.p.m.;

D = alkalinity of sludge to be elutriated, p.p.m.;

W = alkalinity of the eluent, p.p.m.; and

R = wash-water ratio.

The importance of the alkalinity of the wash water can best be pointed out by taking some point on the curve in Figure 1, such as the 3:1 ratio. Here the alkalinity of the elutriated sludge is indicated as 900 p.p.m. for a wash

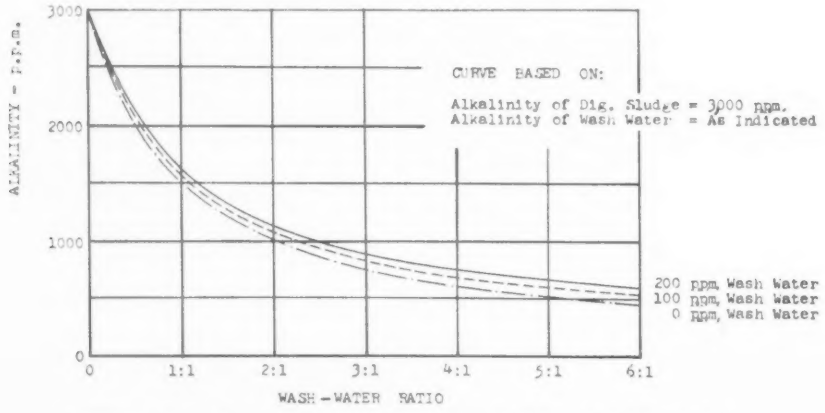

FIGURE 1.—Effect of wash-water ratio on alkalinity of elutriated sludge.

water having an alkalinity of 200 p.p.m. If a water of 100 p.p.m. alkalinity had been used, the sludge alkalinity would have been reduced to 825 p.p.m.; a zero alkalinity eluent would have resulted in a 750-p.p.m. sludge for the same 3:1 ratio. Figure 1 also shows the effect of the wash-water ratio and indicates that there is a diminishing amount of alkalinity removed from the sludge for each added unit of wash water as the ratio is increased. For the 1:1 ratio the alkalinity was reduced from 3,000 to 1,600 p.p.m. and for the 2:1 ratio it was reduced to 1,130 p.p.m. This shows that the first part of the eluent resulted in a reduction of 1,400 p.p.m. and that the second part further reduced the alkalinity by only 470 p.p.m.; similarly, the additional sixth part reduced the alkalinity by less than 70 p.p.m.

The ratio of the eluent used plays another important role in that adequate settling volume must be provided in the elutriation tank. It is obvious that greater tank volumes are required for higher ratios to maintain the same liquid detention time. Where the wash water is scarce, or supplying it is relatively expensive, or a high ratio is required, the use of multi-stage with countercurrent elutriation may result in a more economical design and operation. Usually two tanks are used; the effluent from the second tank (second stage) is mixed with the sludge to be elutriated and allowed to settle in the first stage. First-stage settled solids are then pumped to a mixing box at the beginning of the second stage where fresh eluent (for example, plant final effluent) is added. The savings in water are indicated by comparing Eq. 3b with Eq. 4 (3); the ratio of the water required by the single-stage method to remove the same amount of alkalinity from the sludge is a little over the square of that for the two-stage countercurrent method, as follows:

$$R = \sqrt{\frac{D - E}{E - W}} + 0.25 - 0.5 \quad (4)$$

Torpey and Lang (4) show that as the dry solids surface loadings increase the concentration of solids decreases. This relationship presumes that the volatile matter content is constant. The dry solids surface loading is found by dividing the dry solids that must be disposed of by the area of the elutriation tank or tanks. Where multi-stage countercurrent elutriation is practised these dry solids are divided only by the area of the last stage.

Another factor considered in this paper is the quality of the elutriator effluent to be discharged. It is obvious that a high solids content effluent will act like a decanted high solids digester supernatant in causing a troublesome recirculating solids load. The higher the percentage of solids capture—solids containment—in the elutriator, the better will be the quality of the effluent. A long detention time and/or a low surface solids loading will result in better containment.

The limited plant-scale study at the Bay Park sewage treatment plant yielded information which shows the relationship between the solids containment and two other factors, solids loading in pounds per square foot per day and the liquid detention time in days, that may be combined to form the sludge factor (Figure 2).

$$\text{Sludge Factor} = \frac{\text{Dry Solids Loading}}{\text{Liquid Detention}} \quad (5)$$

The study was made by loading the second stage up to the "breaking point" whenever possible and using the first stage to polish the effluent from the second stage. The breaking point was that combined liquid and solids loading at which the effluent took on a black aspect because of high solids content. Table I indicates that no deterioration took place at the 1:1 ratio; however at the 2:1 wash-water

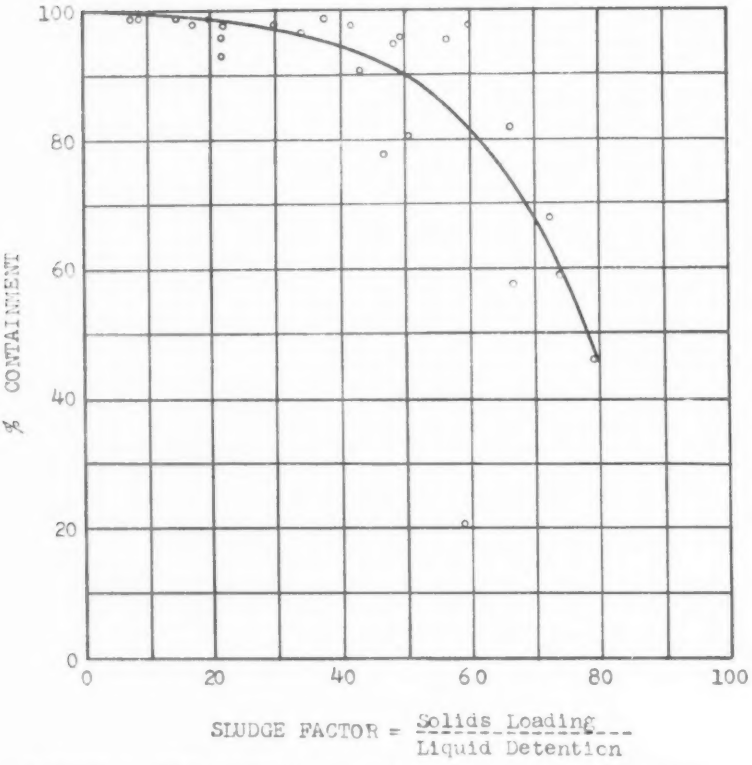

FIGURE 2.—Relationship between solids containment and sludge factor.

ratio there were a few days where, after the breaking point had been reached, a slight reduction in the loadings did not quickly restore the quality of the effluent to a satisfactory level. With approximately the same solids loadings as for the 2:1 test, the tests with the 3:1 and 4:1 ratios yielded successively poorer effluents. During the entire study, hourly sludge blanket soundings were made and averaged for each day to compute the average volume of the sludge blanket. The difference between the tank volume and the average sludge blanket was taken as the average effective volume of the flowing through compartment.

Recently, the volatile matter content was found to be the most important sludge characteristic at the Bay Park sewage treatment plant, where the combined raw sludges averaged more than 80 per cent volatiles and the digested mixture contained 60 per cent. Despite the high volatile matter destruction of 65 per cent, this plant's elutriation and vacuum filtration facilities did not function as designed because of the abnormally high volatile content. Beyond careful digester operation there is little if anything that an operator can do to reduce this sludge characteristic, which plays two very important roles. First, Torpey and Lang (4) indicate that a high volatile content digested sludge does not concentrate as well as a low volatile one. They also show that there is nearly an inverse straightline relationship. Earlier it was pointed out that a poorer concen-

TABLE I.—Operating Data on Elutriation Effect

Date	Digested Sludge (gal.)	Wash-Water Ratio	Eluent (Wash Water) (gal.)	Total Liquid Influent (gal.)	Average Sludge Blanket (ft.)	Liquid Detention (days)	Dry Solids Influent (lb.)	Solids Loading (lb./sq.ft./day)	Sludge Factor[1]	Effluent		% Containment
										Susp. Solids (p.p.m.)	Dry Solids (lb.)	
Nov. 16	23,800	1:1	23,800	47,600	2.7	1.27	7,400	9.5	7.5	270	110	99
17	23,800	1:1	23,800	47,600	4	1.10	7,500	9.6	8.7	230	92	99
19	35,700	1:1	35,700	71,400	3.3	0.79	10,600	13.6	17.2	320	200	98
20	31,800	1:1	31,800	63,600	4	0.83	9,500	12.2	14.7	270	140	99
21	31,800	2:1	63,600	95,400	4	0.55	9,300	11.9	21.6	790	640	93
23	31,800	2:1	63,600	95,400	3.3	0.59	10,100	12.9	21.9	510	410	96
24	35,700	2:1	71,400	107,100	4	0.48	11,200	14.3	29.8	240	210	98
25	35,700	2:1	71,400	107,100	6	0.38	12,400	15.9	41.8	270	240	98
Dec. 2	31,800	2:1	63,600	95,400	4	0.55	9,500	12.2	22.2	240	190	98
3	35,700	2:1	71,400	107,100	5.3	0.42	11,200	14.3	34.0	380	340	97
4	35,700	2:1	71,400	107,100	6	0.38	11,200	14.3	37.7	110	100	99
5	35,700	2:1	71,400	107,100	6	0.38	15,100	19.3	50.8	3,250	2,910	81
6	35,700	3:1	107,100	142,800	6	0.29	10,600	13.6	46.9	1,960	2,340	78
8	19,900	3:1	52,700	72,600	6.7	0.51	7,800	10.0	19.6	104	60	99
9	35,700	3:1	107,100	142,800	6	0.29	13,600	17.4	60.0	210	250	98
10	35,700	3:1	107,100	142,800	6	0.29	11,200	14.3	49.3	370	440	96
11	35,700	3:1	107,100	142,800	6	0.29	12,700	16.3	56.2	450	540	95
12	35,700	3:1	107,100	142,800	6	0.29	10,900	14.0	48.3	480	570	95
13	35,700	3:1	107,100	142,800	4.7	0.34	11,500	14.7	43.2	830	990	91
15	35,700	4:1	142,800	178,500	5.3	0.25	13,000	16.6	66.4	1,560	2,320	82
16	35,700	4:1	142,800	178,500	6	0.23	13,000	16.6	72.2	2,760	4,110	68
18	39,800	4:1	159,200	199,000	6	0.21	13,000	16.6	79.0	4,250	7,070	46
19	35,700	4:1	142,800	178,500	6	0.23	13,300	17.0	73.9	3,650	5,440	59
22	31,800	4:1	127,200	159,000	6.7	0.23	10,600	13.6	59.0	6,300	8,350	21
23	35,700	4:1	142,800	178,500	6.7	0.26	10,900	14.0	66.7	3,100	4,620	58

[1] Solids loading ÷ liquid detention.

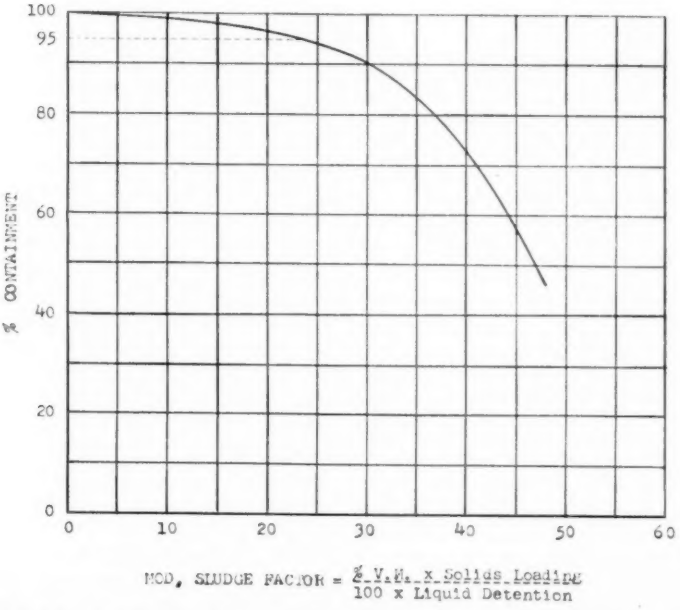

FIGURE 3.—Relationship between solids containment and modified sludge factor.

trating sludge requires a greater elutriation capacity, and that the ferric chloride demand for the alkalinity varies inversely as the solids concentration. Experiences at the Bay Park Plant show that filter yields are nearly proportional to the solids content of the sludge. The second important role of a high volatile matter content was its marked influence on the amount of ferric chloride required for the volatile-solid complex as indicated in Eq. 2.

It is now felt that the volatile matter content should be included in the sludge factor so that it might be reasonably applied to all digested mixtures of activated and primary sludges. It is fully realized that there will be variations among the many activated sludge plants, but it is believed that improved designs are possible, using the resulting curve of containment *vs.* modified sludge factor. Figure 3 shows this hypothetical curve. It was developed from an analysis of the various factors discussed at the beginning of this paper, the limited Bay Park data in Table I and the plant's 60 per cent volatile sludge. The modified sludge factor relates percentage of volatiles, dry solids loading, and liquid detention time, as follows:

$$\text{Modified Sludge Factor} = \frac{\%\ \text{Vol. Mat.} \times \text{Solids Loading}}{100 \times \text{Liquid Detention}} \qquad (6)$$

It follows that with a lower volatile content sludge, but with the same loading and the same liquid detention time, a higher solids containment can be anticipated. Other possibilities are indicated for a lower volatile sludge for the same containment and load factor; either the solids loading or the wash-water ratio, or both, may be increased.

A curve such as Figure 3 can be used both for design and operation of elutriation systems. Since this hypothetical curve is for a digested mixture of sludges from an activated sludge plant, it should be used only for the design of the elutriation facilities for plants utilizing both sludge digestion and the activated sludge process. The considerations originally involved in the design of these processes will yield the following necessary information: the weight of dry solids that must be removed from the digestion system each day or each vacuum filter operating day, and the estimated volatile matter content and the alkalinity of the sludge to be removed.

In the following discussions assumptions have been based on the Bay Park plant experiences. For design: a dry solids loading of 10 lb. per square foot per day is assumed for this type of sludge. This loading divided into the weight of the dry solids will yield the tank's area. Since this sludge does not compact well, it is assumed that the sludge blanket will contain a day's solids contribution. Experience indicates that a 3.5 to 4 per cent sludge can be withdrawn for a 55 to 65 per cent volatile sludge; higher concentrations can be removed for lower volatile sludges. It is assumed that the average concentration of the sludge blanket is about 3 per cent where the removed sludge ranges between 3.5 and 4 per cent. This will aid in estimating the blanket depth. The design estimated sludge alkalinity will allow the determination of the required wash-water ratio and the total volume of the water and sludge mixture per day. Now a desired percentage of containment is selected, say 95 per cent. Experience indicates that this is a very satisfactory level. From the curve of Figure 3 this containment will yield a sludge factor of 23. This sludge factor divided by the product of the design estimated volatile content and the dry solids loading will result in the minimum allowable liquid detention time in days. Now the volume of the flowing through compartment and the total tank depth can be computed. With the sludge factor kept constant, a study can be made of the effect of various

sludge loadings upon tank volume and the iron salt demand indicated in Eq. 1 in order to determine the most satisfactory design.

The same curve when used to control the elutriation process will yield the maximum allowable wash-water ratio for any solids containment. The solids loading is readily computed and the volatile matter is obtained from laboratory determinations.

Summary

The Bay Park experiences indicate that solids undergoing compaction in the elutriator require adequate detention in order to obtain adequate concentration.

The wash water is dependent upon the volume of sludge to be elutriated, the alkalinity to be removed from that sludge, the alkalinity of the eluent, and the allowable liquid detention period.

Adjustment must be made for the volume occupied by the sludge undergoing concentration in determining the liquid detention time.

At the Bay Park plant the volatile matter content appeared to be the most significant sludge characteristic in the operating economy of sludge elutriation and vacuum filtration.

In the design and operation of elutriators the quality of effluent from the process must be given serious consideration if detrimental, high solids recirculating loads are to be avoided.

The limited plant-scale study led to the development of a hypothetical relationship between the quality of the elutriation tank effluent and three factors. These are the dry solids loading, the volatile content of the sludge, and the liquid detention time; they are combined to form the modified sludge factor. According to the experiences at the Bay Park sewage treatment plant, the containment-modified sludge factor relationship can be useful as an aid to the design and operation of elutriating facilities for a digested mixture of activated and primary sludges.

Acknowledgment

The assistance and suggestions of W. T. Ingram in the preparation of this paper are gratefully acknowledged.

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CORRECTIONS

In the paper on "A Simplified Technic for Atmospheric H_2S Studies" (THIS JOURNAL, **26**, 10, 1217; Oct., 1954) the caption for Figure 3 (p. 1222) should read "1952" instead of "1953." Similarly, the caption for Figure 4 (p. 1223) should read "1953" instead of "1952."

In the report on USPHS research grants (THIS JOURNAL, **26**, 10, 1286; Oct., 1954), the affiliation of Daniel A. Okun should read "University of North Carolina, Chapel Hill, N. C.," instead of that given. Also, in the same listing, the affiliation of G. H. Dunstan and R. E. Hungate should be "State College of Washington, Pullman, Wash." instead of as given.

OXIDATION AND STABILIZATION OF SEWAGE SLUDGES WITH OXYGEN AT ELEVATED TEMPERATURES AND PRESSURES

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The destruction of sewage sludges by replacing the bacterial oxidation process by a cheap and rapid chemical oxidation process without removal of the aqueous phase appears to be worthy of study. It has already been demonstrated that aqueous suspensions of materials even as complex as coals can be oxidized by oxygen gas or air at elevated temperatures and pressures (1). The exploratory work recorded here was undertaken to assess the possibilities of stabilizing or destroying sewage sludges by treatment with oxygen gas or air under similar conditions. This work was initiated in the Coal Research Laboratory because of the availability of suitable autoclave equipment and because of previous experience on the oxidation of coals. The extension of this work to acquire the necessary engineering information for the development of a desired continuous process must necessarily be carried out elsewhere, and hence these preliminary results are being made available.

Experimental

The sludge used in this investigation was primary sludge obtained from the Long Road sewage treatment plant, Penn Township, Pa., which serves only a residential area. The several sludges processed varied in total solid content from 4.8 to 6.4 per cent. The sludges were thoroughly macerated in a blender to assist in obtaining representative samples.

Oxidations

All oxidations were performed in a 1-l. rocking autoclave made of nickel for its resistance to alkali. An iron-constantan thermocouple was inserted into a well extending through the autoclave head into the free space of the autoclave. This thermocouple was connected to a recorder-controller to regulate the heat input and hence to maintain the operating temperature at about $\pm 2°$ C.

A 400-g. quantity of the sewage sludge was transferred to the autoclave. In several runs 125 g. of solid sodium hydroxide was added; this amount made the alkaline solution 7.5 N.

The autoclave was closed, inserted into the rocking-type heating jacket, purged twice with 500 p.s.i. of oxygen, and pressured to the oxygen pressure calculated to expand to the desired hot pressure (300 p.s.i.a. or 1,000 p.s.i.a.) at the desired operating temperature. In all runs rocking and heating were started simultaneously. After the temperature reached the desired level it was maintained there for 2 hr. At the end of this time rocking and heating were stopped simultaneously and the autoclave was cooled to room temperature.

The actual operating pressures were the sum of the vapor pressure of the water plus the initial hot oxygen pressures given in Table I. In the runs where alkali was used additional oxygen was added as the oxidation proceeded in order to maintain the partial

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pressures of oxygen constant throughout the run. When no alkali was used carbon dioxide was liberated into the gas phase; inasmuch as it was only convenient to maintain the total pressure constant, the oxygen partial pressure decreased as the carbon dioxide partial pressure increased. The final hot oxygen pressures given in Table I were calculated from the final gas composition.

Analyses of Products

The gases were bled from the autoclave through a wet test meter to measure the total gas volume. Samples were withdrawn from the bleed stream and analyzed for carbon dioxide by the Orsat technique. In the experiments where sodium hydroxide was used no carbon dioxide appeared in the gas phase, since it was present as sodium carbonate in the liquid phase.

The nongaseous reaction products were quantitatively removed from the autoclave and filtered through medium-porosity fritted-glass funnels. A 25-ml. aliquot of the filtrate and washings was analyzed for total alkali-soluble carbon by the wet method (that is, by oxidizing the organic material to carbon dioxide with a refluxing mixture of chromic acid in sulfuric acid). A second aliquot was analyzed for carbonate carbon by acidification with hydrochloric acid. In both analyses the liberated carbon dioxide was gravimetrically determined by absorption with Ascarite in a typical carbon dioxide absorption train. These studies on the distribution of the carbon in the products were made in order to follow the course of the chemical oxidation.

Another aliquot was evaporated to dryness to constant weight to determine the total solids and the residue from this evaporation was ignited to constant weight in a muffle furnace at 600° C. to determine the volatile solids.

The residue from the filtration was dried to constant weight at 104° C., then analyzed for total carbon and for volatile solids by the techniques described earlier.

The pH of each of the filtrates was determined with a pH meter. The colors of the filtrate, which varied from dark browns through pale yellows to colorless, were measured with a comparator, using the Gardner Paint and Varnish Standards.

Discussion

Sewage sludges are readily oxidized by oxygen gas at elevated temperatures and pressures. Temperatures lower than 150° C. and pressures lower than 300 p.s.i. initial partial pressure of

TABLE I.—Oxidations of Sewage Sludges with Oxygen

Temp. (°C.)	O_2 Pressure, Hot (p.s.i.a.)		NaOH, g.	Initial Carbon Recovered in Products (%)			Product				
	Init.	Final[1]		as CO_2	Soluble in Filtrate	Insol. in Residue	Color, Gardner Number[2]	pH	Odor	Initial Tot. Sol. Remaining (%)	Initial Vol. Sol. Remaining (%)
150	300	260	0	8.3	37.9	53.8	13	3.2	Faint motor oil	54.6	53.0
150	1,000	970	0	7.5	50.2	42.3	9	3.7	Faint motor oil	41.7	38.6
200	300	60	0	41.1	30.6	28.3	11	4.1	Faint motor oil	33.6	25.5
250	300	70	0	53.7	29.9	16.4	8	4.4	Faint motor oil	20.1	12.8
250	1,000	610	0	87.0	12.3	0.7	Colorless	4.8	Faint vinegar	11.0	0.9
300	1,000	490	0	91.5	8.0	0.5	Colorless	7.7	Faint pyridine	11.0	0.6
150	1,000	920	0[3]	21.1	26.6	52.3	Green	—	Faint motor oil	—	—
150	300	300	120	17.6	46.9	35.5	8	—	NH_3 + urine	—	—
200	300	300	120	35.4	30.4	34.2	3	—	NH_3 + urine	—	—
250	300	300	120	50.4	21.5	28.1	Colorless	—	NH_3 + urine	—	—

[1] Calculated from Orsat analysis.
[2] Gardner Paint and Varnish Standard (see text).
[3] 20.0 g. copper sulfate added as catalyst to charge.

oxygen were not investigated. At 150° C. and 300 p.s.i. of oxygen less than 10 per cent of the initial carbon is converted to carbon dioxide, but the slimy character and the fecal odor of the sludges are completely destroyed. The elimination of these properties should make utilization or further chemical or physical processing of the partially oxidized sludges less objectionable. The possibilities of stabilization at temperatures and pressures even lower than 150° C. and 300 p.s.i. appear to be worthy of further study.

At 250° C. and 1,000 p.s.i. initial partial pressure of oxygen about three-fourths of the original carbon appears as carbon dioxide and the resulting product is a colorless liquid with only a faint odor of aectic acid and a pH of 4.8. Increasing the temperature to 300° C. effects only a slight increase in the amount of carbon dioxide produced, but the resulting aqueous phase is now basic with a faint pyridine odor; apparently decarboxylation of the organic acids results in the formation of nitrogen bases. It is of interest to note that at 250° and 300° C. less than 1 per cent of the initial carbon remained in the insoluble residue, indicating that negligible amounts of organic material remained insoluble. Furthermore, the volatile solids have been almost completely destroyed, although analysis of carbon in the filtrate indicates that volatile liquids are present. Perhaps at higher temperatures and pressures than 300° C. and 1,000 p.s.i. initial oxygen pressure, or with better contact between oxygen and liquid phase, or with suitable catalysts, complete conversions to carbon dioxide would be effected, with complete elimination of volatile solids and liquids.

One experiment was attempted with copper sulfate, with some catalytic effects as shown in Table I.

When coals are oxidized with oxygen in the presence of water alone, the process resembles a combustion with carbon dioxide as practically the only product; when alkali is added the reaction results in the formation of polycarboxylic acids, which may be recovered for chemical purposes (1). Several similar oxidations of sewage sludge were performed in the presence of sodium hydroxide, but the data (Table I) indicate that the amount of soluble organic carbon in the filtrate was not appreciably increased.

In several runs at 150° and 200° C. alkali was used and oxygen was excluded; the products from these alkaline hydrolyses were dark-brown gelatinous masses whose fecal odors were highly intensified. It appears that the use of alkali, either alone or with the oxygen, is less desirable than treatment with oxygen alone.

The heating of large quantities of water and oxygen or air which would be required for a wet combustion as described would be a serious obstacle to economic operation. With suitable heat exchange equipment much of the heat loss would be prevented and the heat of combustion would be at least partially compensatory. Perhaps at higher temperatures and pressures the residence time in the reaction zone could be lowered to several minutes duration, which would materially reduce the size of the oxidation equipment. Engineering studies are required before the possibilities of this wet combustion method can be fully evaluated.

Acknowledgment

The authors wish to express their appreciation to H. C. Howard, John F. Laboon, H. A. Thomas, and H. A. Thomas, Jr., for their interest and suggestions and to Joseph B. Simsic for many of the analyses.

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GRANULATION OF GROUND GARBAGE

By Ernst Wolff

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During the postwar period, with domestic garbage grinding becoming ever more popular, an increasing number of sanitary agencies have realized that the granulation of the grind should fulfill certain requirements. Large particles are less easily digested because they offer proportionately less surface for oxidation than smaller particles. Very fine parts are difficult to separate out of the water stream, due to the fact that they remain in suspension for long periods. Hence, large proportions of either very coarse or extremely minute particles are unwelcome.

To standardize the grind, granulation codes have been established in a number of communities. These requirements are not uniform, nor do the local testing procedures parallel each other. No common norm exists for test materials and methods such as screening, water flow rates, drying, procedure of feeding disposers or catching the effluent, etc. Granulation codes will only become meaningful when a reproducible test procedure is specified in the requirements. Obviously, it would be most helpful if a test which is also uniform could be adopted. Possibly the investigation recently made by the household sink unit of the National Electrical Manufacturers' Association will help to establish a workable test procedure.

The granulation distribution of ground products has been the subject of considerable study. Especially in more recent years, after many of the present granulation codes were adopted, investigations of the theory of impact grinding have revealed interesting results. Rosin, Rammler, and Sperling (1) have derived a formula by application of the theory of probability and statistical methods. These were confirmed by tests. The resulting exponential function, known as the Rosin-Rammler equation, is:

$$p = 100e^{-\left(\frac{d}{d'}\right)^n} \qquad (1)$$

in which

p = material retained, in per cent;
d = screen opening, in mm.;
d' = absolute size constant;
n = dispersion constant; and
$e = 2.718$ = base of Napierian logarithms.

Other investigators have plotted granulation data on logarithmic paper and confirmed that straight lines result if cumulative percentages retained are plotted against screen openings. The advantage of this graphical system against linear plotting is, that the complete granulation pattern of a grinder can be predicted when only a few data are known, since a straight line is determined by two points. Among those who came to these conclusions are Gaudin (2) and Bond (3), Landers and Reid (4), and Bennett (5). Gaudin also established a formula for granulation. Contrary to Eq. 1, his was not derived and confirmed mathematically, but established by interpretation of actual granulation curves. The values resulting from

TABLE I.—Results of Grinding Tests with Household Garbage Disposer

Sample	Retained on Screen (%)			Passing No. 40, <0.42 mm.
	No. 3, 6.35 mm.	No. 8, 2.38 mm.	No. 40, 0.42 mm.	
Cabbage	1.0	14.3	20.4	64.3
Turnip tops	6.2	30.0	25.0	38.8
Whole corn	8.2	31.4	24.0	36.4

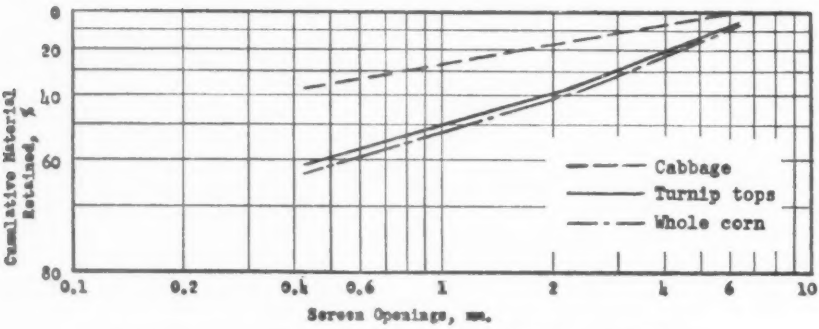

FIGURE 1.—Granulation tests with household garbage grinder.

Gaudin's equation do not agree with Rosin-Rammler data over the entire range, but they, too, are represented by a straight line on logarithmic coordinates.

Table I gives the results of grinding tests with a garbage disposer, using cabbage, turnip tops, and corn on the cob as samples. Screens were stacked under the disposer outlet and were washed under a sprayer, the water pressure and washing time being standardized. Before weighing the samples were dried in a dehydrating oven. The original moisture content of the test material was also established by dehydrating a part of the original sample. The curves for material retained (Figure 1), when consideration is taken of the many variables of the test, closely approach straight lines.

Table II shows some granulation requirements (6); the data are plotted in Figure 2. The values do not result in straight lines where more than two points are specified. In the graphical representation the dispersion is represented by the gradient of the plotted line; the steeper the curve, the less the dispersion. The absolute size constant has been designated as the reading on the screen opening scale where the curve intersects the horizontal of 36.79 per cent material retained. In both these factors there is a wide discrepancy between actual grinding data and code values. This is caused by the fact that code data were not derived from tests, but often were prescribed arbitrarily.

The discrepancy between specifications and what can be achieved in practice could be partly corrected by eliminating the intermediate specification for the No. 8 screen, which value is questionable in any case. Another obvious modification is necessary where a code requires that 100 per cent of the

TABLE II.—Granulation Specified by Various Codes

Code	Permitted on Screen (%)					
	Maximum					Minimum
	¼-in., 12.70 mm.	⅜-in., 9.52 mm.	No. 3, 6.35 mm.	No. 6, 3.36 mm.	No. 8, 2.38 mm.	No. 40, 0.42 mm.
Detroit, Mich.	0	—	5	—	55	100
Los Angeles, Calif.	0	—	35	—	60	—
Philadelphia, Pa.	0	—	10	—	—	95
District of Columbia	—	0	25	—	—	—
U. S. Government	—	—	35	60	—	—

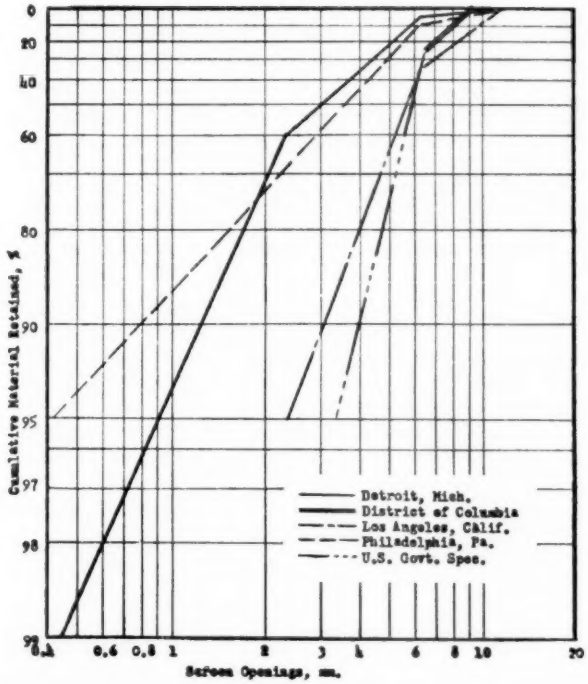

FIGURE 2.—Garbage granulation specifications of various municipal codes.

material must be retained by a No. 40 screen. This value can never be reached by a grinding curve and even 95 per cent, specified in one code, is far removed from actual grinding results.

According to Rittinger's assumption (7), which has become the most widely used rule for estimating the power for grinding, the work required to produce material of a given size from a larger size is proportional to the new surface produced. Consequently the power required for grinding could be substantially reduced if it were possible to minimize the proportion of material ground finer than needed. Engineers have attempted to reduce this proportion for a long time, without success.

It is suggested, then, that after additional testing the present granulation codes should be replaced by a new, uniform code. This should be based on the physical laws of grinding and the results of practical tests; it should also incorporate a testing procedure.

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TEMPERATURE EFFECTS ON PLAIN SEDIMENTATION

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Although much has been written and said about both the theoretical and practical aspects of sedimentation as applied to sewage treatment, the latter phase still needs considerable attention. This appears of value and importance in Egypt at the present time because the Central Government has considered and approved a statement of postwar works in sewerage and sewage treatment plants which revealed an estimated expenditure of £20,000,000 ($57,000,000).

Among the well-known factors affecting sewage sedimentation are:

1. Character of the sewage, including its specific gravity, viscosity, and suspended solids concentration, as well as the size, shape, specific gravity, and hydraulic properties of the suspended particles.
2. Air and sewage temperatures.
3. Design of sedimentation tank, including dimensional factors, sludge and scum removal mechanism, baffling, shape and orientation of inlets and outlets, velocity of flow, and detention period.
4. Biological activities.
5. Electrical effects.
6. Wind.
7. Ageing.

From both the design and efficiency viewpoints, detention period is foremost among these factors. Heretofore the most certain method of determining the required period of retention has been by test on the sewage to be settled.

This paper deals principally with experiments carried out in 1951–53 on raw sewage at Gabal-al-Asfar Experimental Station, Cairo, Egypt, in model sedimentation tanks operated under controlled conditions. The experimental work described in this article is concerned with rectangular settling basins operated at certain rates of flow.

Character of Sewage

The sewage treated may be defined as strong, fairly septic, and domestic. The temperature of the raw sewage varies from 18.5° C. (65° F.) in winter to 31° C. (88° F.) in summer.

The average analysis of the sewage is:

Oxygen absorbed, N/80 $KMnO_4$, 4 hr.	125 p.p.m.
5-day B.O.D.	450 p.p.m.
Suspended solids	490 p.p.m.
Sulfides, as S	25 p.p.m.

The raw sewage was screened and passed through grit chambers before flowing to the sedimentation tanks.

Settling Tank Characteristics

Two rectangular experimental settling tanks were used in these experiments. Each is 4 ft. wide, 20 ft. 2in. long, 10 ft. 2 in. deep at the inlet end, and 1 ft. deep at the outlet. The combined water surface area is 161 sq. ft. The water capacity of each tank is 496.5 cu. ft.

The tanks (Figure 1) are characterized by well-designed features. Table I gives the horizontal velocity and overflow rates for various detention times. Sludge is removed hydraulically; scum is removed manually.

TABLE I.—Flow Characteristics of Experimental Sedimentation Tanks

Detention Periods		Av. Linear Velocity		Overflow Rate (g.p.d.)[1]	
(hr.)	(min.)	(ft./hr.)	(in./sec.)	Per Foot of Effl. Weir	Per Sq. Ft. of Surface
0	30	39.92	0.133	43,000	2,150
0	45	26.61	0.089	28,670	1,433
1	0	19.96	0.067	21,500	1,075
1	30	13.31	0.044	14,335	716
2	0	9.98	0.033	10,750	538
2	30	7.98	0.027	8,600	430
3	0	6.65	0.022	7,170	358
4	0	4.99	0.017	5,375	269
5	0	3.99	0.013	4,300	215
6	0	3.33	0.011	3,085	179

[1] U. S. gallons per day.

TABLE II.—Number of Determinations for Curves of Figures 2 and 3

Temp. Range (° C.)	Susp. Solids (p.p.m.)	Determinations	
		Number	% of Total
18.5–25	150–250	42	9.6
	250–350	91	20.8
	350–450	95	21.7
	450–550	117	26.8
	550–650	42	9.6
	650+	50	11.4
25–31	150–250	62	13.3
	250–350	91	19.5
	350–450	139	29.8
	450–550	49	10.5
	550–650	48	10.3
	650+	77	16.5

Operating Method and Sampling Procedures

The sewage flow was controlled to provide the predetermined detention period by passing the estimated quantity of raw sewage from the inlet pipe into one of the two sedimentation tanks and checking the flow by a floating recorder set up in a chamber well back from the effluent weir. Sludge and scum were removed from the tank or tanks at the beginning of each experiment in the early morning. Then, the known sewage flow was passed and samples were taken after a time equal to or more than that of the ascertained detention period. Separate half-hourly or hourly samples were taken each working day as experimental conditions and laboratory facilities permitted. Corresponding effluent samples also were taken, the time of each collection being determined by the rate of flow to allow for the settling period.

The collected influent and effluent samples were analyzed separately for suspended solids following the usual standard method. This was done to avoid the possibility of flocculation occurring on mixing of samples and to get as many determinations as possible. After the daily samples had been collected, the sewage flow was stopped until the second day.

Experimental Results

As previously mentioned, the detention period was computed volumetrically as required. For each particular time of retention, a large num-

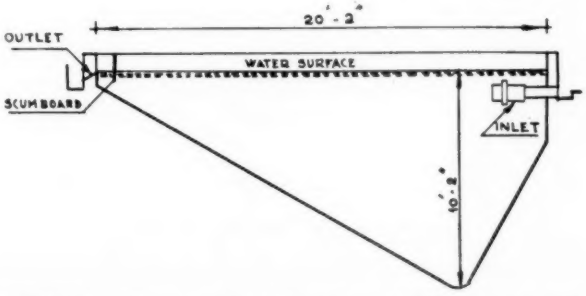

FIGURE 1.—Cross-section of experimental sedimentation tank.

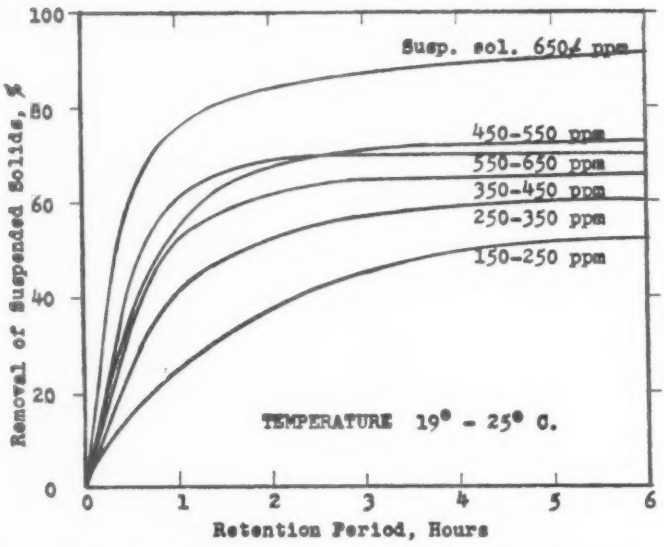

FIGURE 2.—Suspended solids removal *vs.* retention period for temperatures between 19° and 25° C.

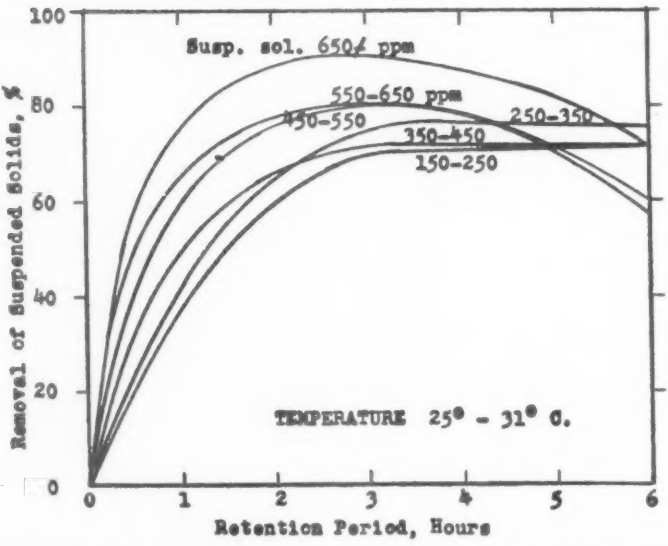

FIGURE 3.—Suspended solids removal *vs.* retention period for temperatures between 25° and 31° C.

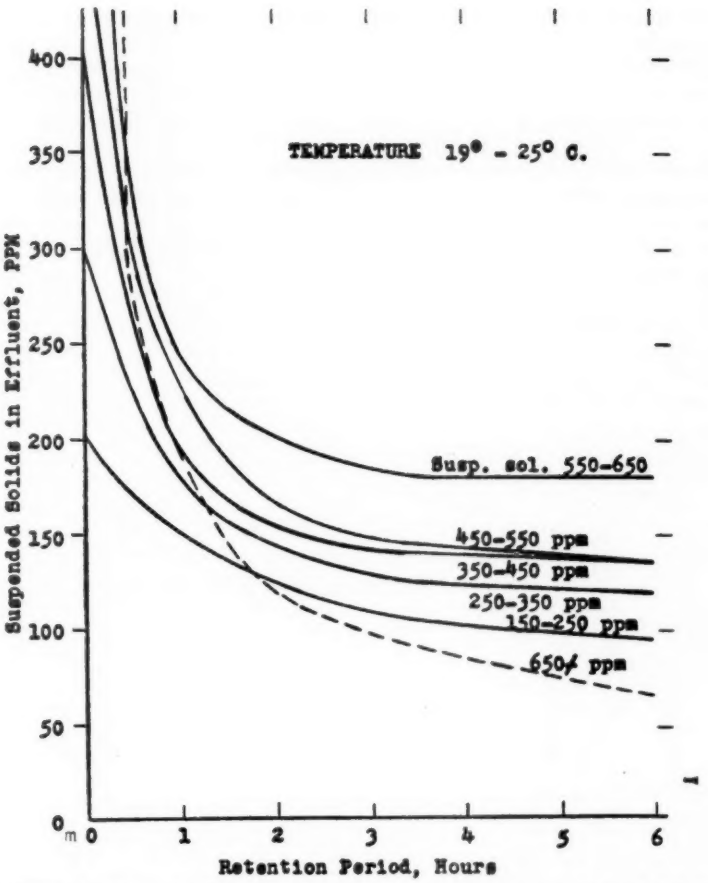

FIGURE 4.—Rate of solids removal for temperatures between 19° and 25° C.

ber of separate samples of both tank influent and effluent were analyzed for suspended solids content. All data thus made available were tabulated according to the strength and temperature of the raw sewage and plotted as curves for temperatures above and below 25° C. No attempt was made to select favorable data or reject unfavorable data. The detention periods used in these experiments varied from 30 min. to 6 hr. Table II gives the number of determinations for the various solids concentration ranges used in preparing the curves. For convenience in future plant performance studies and design, the curves were consolidated into Figures 2 and 3.

Discussion and Conclusions

Because of the variation in raw sewage temperature from summer to winter, it was found necessary to divide the experimental results into two categories. The temperature of 25° C. was selected as the workable border line for three reasons: (a) It is the average temperature between the minimum (18.5° C.) and the maximum (31° C.); (b) the temperature of the raw sewage is equally maintained below and above it through six months of the year; and

(c) the effluent generally is comparatively colder below this temperature and warmer above it with regard to the influent.

The suspended solids concentration in the raw sewage also shows great variation. It was advisable, therefore, to distinguish between six classes according to the strength of the raw sewage in order to determine the relationship existing between the strength of the sewage, the time of retention, and the reduction in suspended solids in settling basins.

According to the literature (1–10), the influence of temperature on the process of sedimentation is of minor importance. This was not justified under the normal conditions existing in Egypt as to the character of the raw sewage and the intensity of temperature. That temperature plays a large part in the tank efficiencies is apparent from a comparison of the rate of solids removal from sewage of equal strength above and below 25° C. (Figures 4 and 5).

Figures 4 and 5 show that the efficiency increases greatly with higher temperatures; that is, within the temperature limits previously mentioned the percentage of removal of suspended

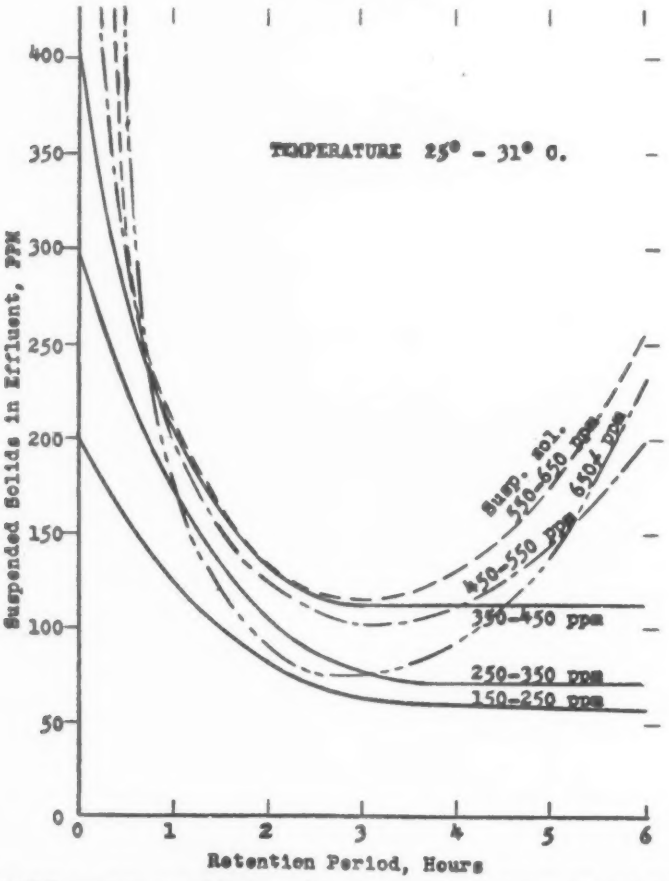

FIGURE 5.—Rate of solids removal for temperatures between 25° and 31° C.

solids is comparatively higher at temperatures above 25° C. The extent is practically equal in magnitude to that attributed to the influence of the concentration of solids in the raw sewage.

Figures 2 and 3 show clearly that the solids removed per unit decreases as the sedimentation period progresses at both ranges, but the percentage removal is always higher in the temperature range from 25° to 31° C. It is apparent, as evidenced by foreign practice, that most of the suspended solids are removed during the first hour of settling at temperatures below and above 25° C. At temperatures above 25° C., however, a relatively greater part of the solids is removed during the second hour of settling.

Another interesting feature is the relation between solids removal, solids concentration in the raw sewage, temperature, and detention time, as indicated by Figure 5. For temperatures above 25° C. and raw sewage suspended solids concentrations greater than 450 p.p.m., the percentage of solids removed is appreciably affected by increasing the settling time beyond 3 hr., with solids removal progressively decreasing with increased detention time. This is due to the rapid generation of gases resulting from the presence of an extraordinary quantity of solids of high putrefaction tendency stimulated by the rise in temperature. The ebulition of gases disturbs the settled sludges, thereby affecting the quality of the effluent.

Tests indicate that the stronger the sewage the greater is the proportionate relative removal of suspended matter. To reduce the suspended matter in the effluent to the same value, however, longer detention periods are required for strong sewages than for weak sewages. This is not always true because for very strong sewage (for example, sewage containing more than 650 p.p.m. suspended solids at a temperature below 25° C. as indicated by Figure 4) less suspended matter remains in the effluent than for weaker sewage, the condition increasing as the settling time increases. At temperatures above 25° C. this feature becomes more evident for sewage containing more than 450 p.p.m. suspended matter as indicated by Figure 5.

The results of the experiments reported herein show that in the temperature range from 19° to 25° C. the amount of suspended matter in the effluent varies roughly as the fourth root of the reciprocal of the detention period for weak sewages, the proportion increasing as the strength of the sewage increases, until the variation becomes a function of the square root at higher levels. At temperatures above 25° C. the remaining suspended solids vary roughly as the square root of the reciprocal of the detention period in the case of weak sewages; for stronger sewages the amount of suspended matter in the effluent varies simply as the reciprocal of the detention period. This emphasizes how temperature affects the rate of settling in sedimentation basins, a fact generally ignored in the literature on the subject.

Summary

1. Comprehensive data on operating rectangular sedimentation tanks under controlled conditions were drawn from the performance of two well-designed settling basins at Gabal-al-Asfar Experimental Station, Egypt, over a 3-year period. The ultimate object of the work was to obtain data for improving the design of sedimentation tanks.

2. Within certain limits, the more dilute the sewage the smaller will be the percentage removal of suspended matter. To reduce the effluent suspended matter to the same value, however, longer detention periods are required for stronger sewages, but after a 3-hr. period depending on the temperature, the effect is reversed.

3. Temperature as normally encountered under present experimental conditions plays an important role in the performance of primary sedimentation

tanks due to the increase of the rate of settling.

4. At temperatures above 25° C., and for strong sewages, an increase in detention period above 3 hr. results in less than maximum suspended solids removal, efficiency decreasing as detention time increases.

5. The percentage of suspended matter remaining unsettled varies approximately as a function of the detention period, depending in large degree on the strength and temperature of the influent.

Acknowledgment

The authors wish to acknowledge the assistance of A. Kayed, Chemist of the Port Said Municipality, who conducted the analytical work at the beginning of the study.

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SHORTAGE OF ADEQUATE TREATMENT FACILITIES STRESSED AT "CLEAN WATERS" PREMIERE

The premiere showing of a revised and vastly improved version of "Clean Waters" was the occasion of an insight into the shortage of adequate treatment facilities needed to prevent pollution of the nation's waterways. Occasion for the film premiere was the Federation's 27th Annual Meeting, held in Cincinnati, Ohio, October 11–14, 1954.

In introducing the film, which is the visual portion of the sewage treatment phase of General Electric's More Power to America program, H. R. Wallrath, manager of the company's contractor and construction industry sales, stated that disposal capacity has not kept pace with rapid city growth of the last decade. He also quoted figures of the USPHS showing that the current national expenditure of $600,000,000 annually for sewage treatment facilities would need to be tripled for the next five years to ease the problem and realistically provide for future population growth.

The size of the job is indicated by the immediate need for 6,700 new sewage plants and 3,500 industrial waste facilities. In addition, many of the present 6,600 plants are inadequate and must be expanded. Recreation, commercial and sport fishing, municipal water facilities, wildlife, water transportation, stock raising, irrigation of crops, and many other facets of the nation's productive and recreational life are seriously threatened.

To combat the lack of public concern with the problem, the 16-mm. full-color film is expected to serve as a tool for use by the small but growing number of associations, conservationists, sportsmen and others eager to create a public awareness of the consequences of unchecked water pollution. The film is supplemented by a two-color, 34-page bulletin (GEA–6069) entitled "Clean Water—And How to Get It," designed to help civic leaders, municipal officials and sewage treatment experts dramatize to their communities the urgency of providing proper sewage treatment—and how to go about getting it.

Industrial Wastes

WASTE CONTROL BEGINS WITH PROCESS OPERATIONS *

By B. W. Dickerson

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In the early days of this country both industry and municipality felt clothed with the inherent right to discharge their waterborne wastes untreated into the nearest watercourse. In those days, cities were small and industry was not the centralized giant that it is today. In most cases the streams were able to assimilate the loadings imposed and no undue pollution problems resulted. As communities grew and industry developed, however, the streams became overloaded to the point where many were highly objectionable and once pleasant rivers became a nuisance.

Along with this growth came a greater realization by the people of their inherent right to the use of these natural resources for recreation and pleasure and with this development came a demand for their improvement. Such a demand was reflected in legislation setting standards for the various watercourses and providing for their enforcement by the regulatory agencies.

Industry has a real stake in this whole program, for if it is to thrive and develop it must first of all be a good citizen in the community. The day has long passed when the "town-be-damned" attitude can be taken. Today good public relations are a must, and woe to the industry that does not have them. And good public relations include waste-water discharges that meet existing stream requirements. An incensed townspeople aroused by a nauseating stream can and has developed an "industry-be-damned" attitude, which for its correction has taken years to overcome. Furthermore, costs have been incurred which could have been materially reduced had a sane approach to the problem been taken earlier. Industry must, therefore, put its house in order along this line and to do so means full compliance with existing pollution abatement programs.

Development of Problem

Before any intelligent waste control program can be established two factors must be considered: (a) the magnitude of the plant load, and (b) the requirements of the receiving stream. The first requires a thorough and comprehensive study of the magnitude and volume of all the waste waters discharged and should cover every operation, if possible. The second, the receiving stream may already be covered by existing regulatory standards or be based on the assimilative capacity of the stream, which is by far the sanest approach to an economical and wholly satisfactory program of stream clearance. It may be essential that a stream survey be made to develop these data and a cooperative program between industry and the agency to obtain these data will pay dividends to both and provide the industry with a real evaluation of the needs for waste reduction.

With these basic data at hand, a

* Presented at 26th Annual Conference, Pennsylvania Sewage and Industrial Wastes Association; State College, Pa.; Aug. 25–27, 1954.

preliminary estimate of the cost of necessary treatment can be established. This estimate is most essential, as it usually is the leverage required to initiate the necessary studies for reduction where it needs to be made most—right in process operations. Process control and waste recovery are just as much a treatment plant as the physical plant on the bank, for each has the same result—namely, reduction of wastes.

With a cost estimate for a waste plant, management has a yardstick by which improved operations can be measured and the interest in reducing a capital expenditure can be the driving force in process operation improvements.

As previously stated the thorough and comprehensive study of the overall plant waste load is the first step, because only by such a study can any intelligent approach to waste reduction be made. Here appear the many segments, large and small, which go to make up the whole, and an indication as to which operations may yield the greatest return. These loads can be broken down into two phases: (*a*) direct waste resulting from the chemical reaction itself; and (*b*) indirect waste resulting from spills, leaks, drips, and generally sloppy operation.

It may be difficult to develop a breakdown of these two phases in the study due to the general physical arrangement of the plant. If the breakdown can be obtained, however, it will allow a better appreciation of the magnitude of the two problems. It also can indicate why yields may not be as high as they should be. Thus an incentive can be developed to correct this phase and the waste survey, which may not have been looked upon with too much favor at the start, receives the type of support most helpful in pushing through the program.

Where the split cannot be made originally, it becomes necessary to proceed with a tightening up of the whole operation and then a restudy of the waste load to determine the reduction effected.

Primary Correction

Indirect losses can usually be reduced quite easily, for they are generally the result of poor housekeeping. They reflect poor maintenance, indifferent operators, and a lack of appreciation of what is being thrown away.

Many sources of indirect losses include valves, pumps, catch tanks, and the like. By repacking pumps, installing catch pans under pumps which must have some leakage from stuffing boxes, enlargement of catch tanks, installation of covers, repairs to float valves, and proper sized piping, reduction can be made. Where sloppage must be tolerated by the nature of the equipment, the installation of necessary sumps will allow collection at the site with recovery or proper disposal, rather than flowing to the nearest sewer and adding to the load. This wastage is product, and by collection and re-injection, losses can be reduced, yield improved, and waste load minimized.

It may seem that overemphasis is being placed on this program, but plant studies have shown this factor to be as high as 20 per cent, which can mean real dollars both in raw material and finished product. One instance is known where a pound of waste B.O.D. was equivalent to a pound of product.

The human element is not so easily corrected, for this means a change in ways and resistance is usually encountered. Here an educational program is the best approach. This should show the need for waste reduction in losses in product which mean lost income; losses in raw material which mean increased costs of operation; and, finally, additional capital investment for waste treatment. This last, in effect, reduces available funds which could more effectively be used in providing additional process expansion and thus more income for the company. Properly set

up and administered, such a program will develop a waste consciousness in the personnel and it is surprising how their attitude will change. This is not idle talk, for the results have been seen in plants of the author's company and it is known that others also have experienced it.

Secondary Correction

With this phase corrected, attention is directed toward the toughest problem, the direct waste discharge. Here resistance will be met immediately, for process personnel are sensitive to criticism and usually have a stock answer: "It cannot be improved." Here, also, considerable study may be required to effect improvement in equipment operation, as well as to show the need for capital investment necessary for its completion. This is no one-sided problem, but requires close and effective cooperation from process and waste engineers. It centers on yields, losses, and equipment design. It is not something that can be developed in a hurry.

Lower yields may be due to poor control by the operators or poor sensitivity of control instruments; sometimes, to insufficient instruments to allow the proper degree of control necessary. Equipment may be operated at too high a rate, resulting in high carryover and excessive loss from lower reaction rates. Again, what was considered a satisfactory design may not be operating as expected. An example of this would be evaporators where high entrainment has developed, resulting in heavily contaminated condensate. Correction of these problems may not be easy, especially with overloaded equipment, since this usually means additional new units to carry the load. Sometimes, however, serious study will show modifications which will be effective at reduced cost. Where evaporator entrainment is the problem it can generally be reduced rather inexpensively by the use of entrainment separators.

Engineering Development

Another pertinent factor arises in design, especially of recovery equipment. Usual figures considered range from 90 to 95 per cent. The last 5 per cent may not seem significant, but the waste problem resulting from this value, especially where large quantities are involved, can easily equal the additional cost of process equipment installation. Thus, additional efficiency means recovery of raw product, resulting in a saving and reduction of a waste problem with its attendant expense. In one such installation the added cost approximated $500,000 and the B.O.D. load was reduced about 18,000 lb. The cost of treating this load, however, was greater than the cost of the equipment installation.

In looking into the over-all waste picture, the possibility of reducing liquid volume is also of value for it means less water to handle. Reduction in wastes volume means increased concentration, but in the majority of cases it will not be serious. Barometric condensers are widely used in the chemical industry. The cooling water used becomes contaminated, adds to the over-all volume and will not allow for re-use. Installation of surface condensers prevents contamination of the cooling water and the waste volume becomes that of the condensate. This small volume may allow an alternate method of disposal from this operation at an attendant saving in over-all cost. However, when mixed with the other waste streams, it adds little to volume but does add the same total B.O.D. as originally.

This method may not be applicable when sticky or gummy products would coat the tubes of the surface condenser. It has another drawback in that the same high efficiency may not be obtained. However, where water conservation is practiced the uncontaminated flow from such units may be added to the circulating systems for makeup, and may, if the temperature rise is not

too high, be utilized for additional cooling at higher temperatures.

There are costs involved by such usage in replacement of equipment, especially where existing. In new installations, however, the difference in cost may be small in the over-all picture. It is a problem in over-all economics and must be so considered, but its judicious use can result in lower waste treatment plant expense.

Process Investigation, Revision, and Development

Passing to another phase of the problem, there is the possibility of re-use of a portion of the waste stream. This is not always possible; however, it is one that should not be overlooked. Here again the comprehensive survey is of value in that it sets up each waste stream and allows its proper analysis. Study of the composition and volume will indicate possible value for re-use. However, much more work is generally required, beginning in the laboratory and passing to pilot operation to determine the effect on quality of final product. When this is favorable, final evaluation is made and, if satisfactory, full-scale use can be instituted. In one case the waste load was reduced 12 per cent, amounting to more than 800 lb. of B.O.D., with resultant savings in raw material and additional capacity in the waste plant for further expansion.

In casein manufacture, counter-current washing, re-use of effluent liquor for acid dilution, and collection and re-injection of leakage and drips has resulted in the total waste load being reduced about 90 per cent.

Recovery of useful product is another angle which should be given serious thought. It may not always be feasible and in many instances cannot be considered. However, there are places where it can be done. Recaustization in the paper industry provides new sodium hydroxide and the same is true in cotton linters purification. By its use a formidable waste problem is eliminated and raw product is recovered. There are many factors involved in a final evaluation of this, but where a black liquor problem must be eliminated recovery is the most economical solution.

White water purification in the paper industry is another instance where recovery of a useful product is effected. The settleable solids are used again for filler and in some instances the clarified effluent can be added to the make-up water. Thus, savings are made in product and water costs, and additional loading on the waste plant is removed.

Lastly there is the subject of new product development. This is not new and has been vastly overrated, but it still merits consideration. One such operation is the manufacture of sodium formate from a waste discharge resulting from pentaerythritol manufacture. This discharge was highly toxic and produced a B.O.D. load of more than over 5,000 lb. per day. The new product removed the waste load and produced new income for the company.

Miscellaneous Phases

One other phase that is receiving more attention today is the possible use of certain waste discharges small in volume but high in organics, especially hydrocarbons, which have a B.t.u. value sufficiently high to allow their use as an auxiliary fuel in the boiler furnaces. Thus, a source of fuel is obtained for process steam and an objectionable waste problem is eliminated.

Another pertinent point is contamination of raw material. In at least one instance this has had a direct bearing on a plant waste load.

In the manufacture of pentaerythritol, formaldehyde is a major raw product. It is produced by the oxidation of methanol, the amount of methanol remaining in the formaldehyde being dependent upon the final purification. Small amounts of methanol are

always present in the material as received and show up in the waste-water discharge. A change occurred in the raw material which showed a much higher residual methanol content than previously.

This factor entered the over-all picture just at the time enlargement of the waste treatment facilities was completed. The design has been based on existing operations with some excess capacity, but not enough to handle the large increase which took place. To meet existing stream requirements, which were very severe, and since it was impossible to obtain lower residuals at the time, additional facilities were necessary and their construction added to the over-all cost of the waste treatment facilities. This experience suggests the necessity of studying this phase in the over-all picture.

Still another phase of process operation involves use of substitute products in the raw material stage which will reduce the oxygen demand of the waste effluent. In the warp size operation in cotton textile manufacture, for example, the partial substitution of certain cellulose derivatives for starch will result in lower B.O.D. values than with starch alone. Thus, when the assimilative capacity of the stream is to be utilized and time is necessary for proper dilution, oxygen depletion can be held within the limits required. Under such conditions a treatment plant may be eliminated.

Conclusion

It is hoped that the foregoing discussion has been able to show just how waste reduction is tied up with process operations, and that by careful and thorough study, open-mindedness, and close cooperation by process and waste engineers, economical solutions to industry's waste problems can be developed. Lest there be any misunderstanding, it is not intimated that a treatment plant can always be eliminated, but it certainly can be reduced in size and cost, and in those instances where stream conditions are favorable, it may be eliminated. Waste treatment is expensive. Therefore, it is the duty of the waste control engineer to do everything in his power to hold the capital investment for such to a minimum, for unless he does he will not be doing his job. A corollary to this is a sympathetic attitude by the regulatory agency in allowing the necessary time to an industry which is honestly striving to accomplish such a program, as well as in recognizing that such action means just as much in the final picture as the treatment plant on the river's bank.

PRE-DOCTORATE FELLOWSHIP AVAILABLE

Announcement has been made of the availability of a predoctorate fellowship in the Department of Preventive Medicine and Public Health, University of Texas Medical Branch, Galveston, Tex. Research studies are to be carried on in disinfection of water, wastes, and air, with full-time study toward a graduate degree permitted.

Details of necessary qualifications, stipend, and other particulars may be obtained from Professor C. H. Connell, Department of Sanitation, University of Texas Medical Branch, Galveston, Tex.

INDUSTRIAL SEWER MODIFICATIONS TO REDUCE POLLUTION *

By Carl J. Swartz

Chief Chemist, L. F. Grammes and Sons, Inc., Allentown, Pa.

The present major activity of L. F. Grammes and Sons Co. is the manufacturing of decorated metal products. The factory, located in Allentown, Pa., at the confluence of Jordan and Little Lehigh Creeks, manufactures many different articles produced almost entirely on a custom contract basis.

Such articles as television picture tube masks; instrument control panels, decorative trim, and escutcheons for television, radio, refrigeration, automotive, and allied industries; advertising specialties, such as calendar pad holders, bottle openers, and wall plaques; auto club emblems; a line of metal giftware; and many other items require use of a large number of mechanical, metallurgical, chemical, and electrochemical processes.

Manufacturing processes include stamping, embossing, wire forming, lithography, photography, etching, electroplating, electropolishing, anodizing, parkerizing, pickling, tool making, heat treating, screen printing, organic coating or enamelling, and vitreous or glass enamelling.

Although originally engaged in the manufacture of specialized machinery, emphasis in late years has been on expansion of the stamping, plating, and surface treatment techniques for metals of many types. With company growth, the rinse or wash water use also grew, for in decorative treatments thorough cleansing between operations is necessary for obtaining satisfactory and acceptable visual effects which will endure. Since the quantities of objectionable materials to be disposed of were small and a fairly plentiful supply of water was available from the company's own deep wells, an abundance of water has always been used to prevent staining, tarnishing, and contamination of successive treatment baths in keeping with the policy of maintaining the concentration of harmful constituents in the effluent at a low level by dilution.

Magnitude of Problem

Because of the variety of operations in the plant and the custom nature of the work, where the combinations of operations rarely repeat exactly, even on two successive days, it was difficult to know how to take better preventive measures without spending large sums of money for equipment which would be used only infrequently and which would be a serious economic burden in the highly competitive type of work. The physical problem due to the plant layout resulting from a mushrooming type of expansion was considerable.

At the time there were four drainage lines discharging to Jordan Creek and one discharging through an old storm sewer to Little Lehigh Creek. In addition, there were the normal connections to the city sanitary sewer system for sanitary purposes only. Sampling by the State Department of Health indicated that the combined wastes were objectionable because of greater acidity, metal content, and total solids load than were permissible under the existing stream standards. No cyanide was noted in these analyses, but because cyanides were in use, a potential for existence was present.

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Table I gives the results of the analyses and the calculated effect on the stream, together with the state and federal standards for drinking water (1).

As part of the normal procedure, the company was notified to submit plans for a treatment plant by a given date. As previously pointed out, the situation aroused considerable concern for several reasons, including (a) the physical layout (that is, the distribution of facilities); (b) the variety and number of processes involved; (c) the volume of water used and discharged; (d) lack of space for treatment facilities; (e) lack of definite knowledge of the effluent or the stream standards; and (f) the cost thought to be involved in treatment installations as tried by other companies without complete success.

After considerable internal study and analyses of what could be done, it was decided that the assistance of a firm of competent consulting engineers specializing in these problems, was necessary and desirable.

Waste Survey

The next step was to make a comprehensive survey of the situation. First the purposes for which chemical solutions are required were listed. These include etching of brass, stainless steel, aluminum, and zinc; stripping of chromium prior to etching; chromium plating of sheets and stampings; color and pattern plating; silver plating and oxidizing of stampings; statuary bronze oxidizing; electropolishing, bright dipping, and anodizing of aluminum; black nickel, zinc, and copper plating; silver plating of sheets; barrel nickel plating; barrel zinc plating; parkerizing; pickling for organic enamelling, bright finishing, and hard or glass enamelling; electropolishing of stainless steel; water demineralizer and water softener regeneration; blackening of steel; and treating of aluminum for enamelling. All processing tanks, including plain water rinses, which were not already numbered for laboratory control purposes, were assigned numbers, and capacities were listed. These numbers, with several short gaps for possible later additions, total more than 300. The next step was to prepare flow sheets to show exact movement of work with the thought that possibly some condensation might be possible. Because these normal processes totaled some 20 different combinations of solution usage, diagrammatic drawings were prepared for clarification.

Departmental floor layout drawings were made to scale and combined as follows:

1. Etching and main plating department, where sheets and larger stampings are processed.

TABLE I.—Quantities Discharged, Resulting Increase in Stream Concentrations, and Comparative State and Federal Drinking Water Standards

Contaminant	Quantity Discharged (lb.)		Increase in Stream Conc. (p.p.m.)		State and Federal Drinking Water Standards (1) (p.p.m.)
	4/17/50[1]	7/20/50[2]	4/17/50	7/20/50	
Cr	10.7	17.75	0.06	0.1	0.05
Cu	10.8	44.0	0.06	0.25	3.00
Fe	44.96	103.00	0.27	0.60	0.3[3]
CN	0.0	0.0	0.0	0.0	0.0
H_2SO_4	0.0	0.0	0.0	0.0	—
Alkalinity	0.0	0.0	0.0	0.0	120.0

[1] Flow of 424,800 gal. between 7 AM and 12 M.
[2] Flow of 680,000 gal. between 7 AM and 12 M.
[3] Combined total of Fe and Mn.

2. Aluminum bright dipping, electropolishing, and anodizing departments, both manual and conveyorized, where both sheets and stampings are processed.

3. Barrel plating and other bulk treatment processes, such as parkerizing, pickling, dipping, and tumble finishing of small parts.

An over-all combined floor plan was made to show existing drainage gutters and outlets.

A separate tabular listing was made by tank number, in sequential order, of those solutions which may be major sources of objectionable ingredients in the waste waters. This listing included volume and name of solutions, the method of loss or direction of transfer out of the tank, the principal contaminants and their concentration in the tank, plus the normal analysis of the solution. The list included the major solutions carrying metals and metal salts in relatively high concentrations which are considered objectionable in very low concentrations and consisted for the most part of baths that are rarely if ever replaced and where losses are usually due only to dragout.

A second listing was similarly compiled of the solutions containing only minor types of contaminants, such as the simple acids and alkalies, which are used usually at relatively low concentrations. This group of baths includes the cleansing, pickling, and surface preparatory solutions for the main processing operations and because of their very function must be discarded and replaced at intervals like any other washing or cleansing baths.

The acid baths were again listed separately to show tank number, content, frequency of discard, volume, and sulfuric acid equivalent. A comparable listing was made of the alkaline baths showing the alkali equivalent as pounds of sodium hydroxide.

A third listing was compiled for those treatment baths requiring frequent discharge and containing chromium salts.

The survey included a comprehensive study of all rinse tanks and actual measurement of rate of water flow through most of them. For the few that could not for physical reasons be measured, comparisons were drawn with other tanks of like size, use, etc., and it was possible to make what were considered relatively accurate estimates of the flow rates.

Included in the survey was a comprehensive study of the effluents discharged to Jordan and Little Lehigh Creeks. A 90° V-notch weir was placed on the storm sewer discharge to the Little Lehigh, flow was measured, pH measurements were made, and weighted samples were taken individually on each outlet for the operating and non-operating periods. Complete analyses were made on weighted composites of all composites. Results of the survey are given in Table II. Variations in flow rate ranged from about 0.97 to 0.82 m.g.d., with a total flow of 0.64 m.g. during the operating period (7 AM to 12 M) and 0.24 m.g. during the non-operating period (12 M to 7 AM). During the 24-hr. survey period pH values were as follows: Minimum, 2.9; maximum, 8.83; composite during operating period, 6.7; composite during non-operating period, 7.72; and composite during entire period, 6.9.

Corrective Actions

To prevent the objectionable products from going to the stream the following alternates were given consideration:

1. Construction of holding tanks and treatment of the entire quantity of effluent in suitably sized batches after complete analysis of each batch.

2. Segregation of the effluent into various types and treatment of each type before discharge to a lagoon for

TABLE II.—Contaminant Discharge and Resulting Increase in Stream Concentrations, Based on 15-Minute Sampling Interval

Contaminant	Quantity Discharged (lb.)				Increase in Stream Conc. (p.p.m.)			
	Operating Period[1]	Non-Oper. Period[2]	24-Hr. Comp.[3]	Grammes Estimate[4]	Operating Period[1]	Non-Oper. Period[2]	24-Hr. Comp.[3]	Grammes Estimate[4]
Cr	2.90	0.0	2.9	26.94	0.02	0.0	0.12	0.11
Cu	22.62	0.17	22.79	9.32	0.13	0.002	0.09	0.04
Fe	21.59	0.42	22.01	12.56	0.12	0.006	0.09	0.05
CN	0.16	0.03	0.19	0.14	0.0009	0.0004	0.0008	0.0006
H_2SO_4	0.0	0.0	0.0	89.05	0.0	0.0	0.0	0.38
Alkalinity	0.0	0.0	0.0	17.02	0.0	0.0	0.0	0.07

[1] Flow of 680,000 gal. between 7 AM and 12 M, Sept. 19, 1950.
[2] Flow of 250,000 gal. between 12 M and 7 AM, Sept. 20, 1950.
[3] Composite of all composites, representing 930,000 gal.
[4] Grammes estimate of possible total for 744,216 gal. per 24 hr.

solar evaporation and separation of solids.

3. Separation of the unpolluted waters for discharge directly to the stream and collection of the remainder for treatment.

The third procedure was the one chosen. Any move toward reduction of the volume to be treated would certainly result in the most practical solution to the problem. The objective was to eliminate discharge to the stream of the most objectionable class first and then the others in order of decreasing importance.

While the survey was in progress, the possibilities were explored with the city of Allentown for acceptance of the plant's waterwash paint spray wastes in the city sanitary sewer. After sampling and examination of these wastes by the city chemist, agreement was reached on a method of treating them in their individual operating tanks. The drain lines then were rearranged to pipe each to the nearest sanitary sewer within the factory. Treatment of these wastes required only neutralization of the alkali and removal of the bulk of the suspended solids. This is easily accomplished during regular clean-up periods and eliminates from the discharges to the streams the products responsible for oxygen demand factor.

The first classification to receive consideration was the one listing the rinses which potentially could carry cyanides.

TABLE III.—Total Pollutant Load Possible (from Measurements, Estimates, and Analyses of Individual Surveys)

Waste Source	Average Quantity[1] (g.p.d.)	Quantity Discharged (lb./day)					
		Cr	Cu	Fe	CN	H_2SO_4	NaOH
All rinses, plus concentrates	744,216	26.94	9.32	12.56	0.140	89.05	17.02
All rinses	743,706	8.32	9.32	12.56	0.088	0.0	0.0
Concentrates	510	18.62	0.0	0.0	0.055	89.05	17.02
Cyanide-free rinses	685,386	8.32	9.24	12.56	0.0	0.0	0.0
Cyanide rinses plus conc.	58,830	18.62	0.088	0.0	0.143	89.05	17.02
Rinses without appreciable metals, plus conc.	586,023	0.75	1.44	2.30	0.0	0.0	0.0
Cyanide rinses, plus rinses with appreciable metals, plus conc.	158,193	26.19	7.88	10.26	0.14	89.05	17.02

[1] Estimates of possible totals.

Static recovery rinse tanks were in use after each cyanide bath, but the second rinse was of the free-running type. The survey showed that the use of cyanide in processing is small and the necessary rinse volume is small in proportion to the total rinse volume (59,000 *vs.* 750,000 g.p.d.) Results of the classification studies are given in Table III.

Because of the rigid ban on all cyanide, regardless of concentration or load, a separate drainage line was installed connecting all of these rinses to discharge through a 60° V-notch weir by gravity to the city sanitary sewer. This was done with full approval of the city authorities after tests and analyses showed the concentration at the disposal plant to be safe on minimum daily total inflow volume.

The total daily load for the cyanide rinses plus concentrates (Table III) gave the following increases in concentration for sewage plant minimum inflow for the preceding 1-year period: Cr 0.240, Cu 0.0012, CN 0.0018, H_2SO_4 1.147, and NaOH 0.219 p.p.m. Corresponding concentration increases for the average sewage plant inflow during the same period were: Cr 0.187, Cu 0.0008, CN 0.0014, H_2SO_4 0.898, and NaOH 0.171 p.p.m.

Following segregation of the cyanide rinses, all original process drainage lines were connected so as to consolidate waste waters requiring disposal to the main effluent line to Little Lehigh Creek. This simplifies inspection and supervision of internal controls on waste disposal and utilizes natural neutralization of the acid with the alkaline rinses.

The remaining phase for completion of corrective measures was installation of the drainage line for the concentrates which must be discarded at intervals. These concentrates primarily consist of the acid and alkali cleaning solutions noted before, plus several pickle solutions containing bichromates. The average estimated daily volume with all processes operating simultaneously is about 510 gal. A special portable pump with long intake and outlet hoses is moved to a convenient location between the tank to be emptied and the nearest T opening in the concentrates drainage line. The line, which is constructed of vitrified clay pipe encased in asphaltic pitch and protected by a wood box throughout its entire length, carries the discards by gravity to a common sump under a shipping platform.

After a tank is emptied at least an equal quantity of water is pumped to the drainage line and sump. The resultant solution is mixed by bubbling compressed air through it to take advantage of the neutralizing action of acid and alkaline solutions to maintain the pH between 4.0 to 9.0 suitable for pumping into the city sanitary sewer. The approximate capacity of this sump is 4,000 gal., but the average daily discard is only 510 gal., so it is obvious that the excess capacity can be used advantageously for additional dilution before pumping to the sewer or as a holding tank for actual discard in any one day at a rate greater than 510 gal. so as not to obstruct production peak requirements.

These concentrates are pumped by means of one of two positive lift pump at a rate of 2.0 to 2.6 g.p.m. to another short drainage line to the city sanitary sewer. The pumps are wired so that either can be used merely by the flip of a switch. The pump which is connected through the switch for operation is controlled by means of an air-operated recording controller actuated by the level of solution in the sump. If for any reason the liquid in the sump reaches a predetermined high danger level, a red warning lamp in the operating areas warns the supervisor or operator that he must stop pumping solution to the sump until the level has dropped to a safe range.

Checks and controls to insure that

the system is working as intended are arranged as follows:

1. The water wash spray booth discharges are handled routinely by the supervisors in charge, who refer problems to the laboratory for advice. The total volume of 2,000 gal. maximum per week in relation to the minimum sewage inflow of 9 m.g.d. to the disposal plant is so low that no extra precaution is deemed necessary.

2. The non-objectionable waste waters pass through the 90° V-notch weir previously mentioned and are discharged to Little Lehigh Creek through an outfall pipe extending into stream for ready dispersal with stream waters. This flow can be measured visually at a glance by the appointed laboratory staff member, and the discharge is under regular surveillance visually and by spot check analyses for pH, hexavalent and trivalent chromium, ferrous and total iron, and copper. Complete weighted composite samples covering the factory operating period are taken quarterly at the weir outflow for determining the effect of the load on the receiving stream at the low flow of 32 m.g.d.

3. Rinses containing cyanide discharged to the city sanitary sewer are spot sampled, especially when operations might indicate higher than normal activity with the processes using cyanides. Regular inspection of flow records are made and the volume is reported quarterly to the city engineer's office for his inspection and billing purposes.

4. Discharge of concentrates to the city sewer is checked daily and spot check analyses are made to calculate the effect at the disposal plant based on the minimum sewage inflow.

Summary and Conclusions

All of the elements which are objectionable in the plant's waste-water discharges to the stream have been practically eliminated from that effluent. Table IV compares the results of gaging, sampling, and chemical analysis of effluent to Little Lehigh Creek before and after the drainage line changes, together with the corresponding effects on stream concentrations.

A check survey on November 3–4, 1953, showed that flow during the operating period totaled 0.49 m.g.; during the non-operating period, 0.17 m.g.; and during the 24-hr. test period, 0.66 m.g. During the 24-hr. survey period pH values were as follows: Minimum, 5.01; maximum, 8.3; composite during operating period, 7.23; composite during non-operating period,

TABLE IV.—Comparison of Quantities Discharged[1] and Resulting Increase in Stream Concentrations[2] Before and After Drainage Line Changes

Contaminant	Quantity Discharged (lb.)		Increase in Stream Conc. (p.p.m.)		State and Federal Drinking Water Standards (1) (p.p.m.)
	Before Changes[3]	After Changes[4]	Before Changes[3]	After Changes[4]	
Cr	26.94	1.442	0.11	0.0061	0.05
Cu	9.32	8.658	0.04	0.0371	3.00
Fe	12.56	3.159	0.05	0.0135	0.30[5]
CN	0.140	0.0	0.0006	0.00	0.0
H_2SO_4	89.05	96.187	0.38	0.404	—
NaOH	17.02	—	0.07	—	120.0

[1] Waste volume before changes, 0.744 m.g.d.; after changes, 0.661 m.g.d.
[2] Stream flow, 29 m.g.d.
[3] From Table II.
[4] Nov. 3–4, 1953.
[5] Combined total of Fe and Mn.

8.12; and composite during entire period, 7.68. The decreased pH ranges and flows are readily noted by comparison with the results of the "before changes" survey.

The methods of control outlined keep the system and its effectiveness of operation under constant surveillance so that if any unexpected trends or deviations develop they will be noticed immediately and steps can be taken at once to prevent contamination of the receiving stream.

Experience in the operation of this system has shown that actual volumes of waste waters are lower than the theoretical or anticipated volumes based on the original survey. The lower volumes were to be more or less expected, because the survey was predicated on all processes being worked at average capacity simultaneously.

Records for 154 operating days since completion of all the changes show that the average daily flow to the sewer has been only 5,147 gal., with a maximum of 25,477 gal. for a single day as against the 58,530 gal. anticipated and provided for. If the daily volume of 0.75 to 1 m.g.d. of liquids had to be treated, the installation required would have cost from $250,000 to $500,000 and the estimated operating cost might have totaled $50,000 annually. The cost for the drainage line changes was approximately $50,000 and operating cost, aside from labor, on the basis of municipal sewer charges of $0.07 per 1,000 gal. has not been over $7.00 per day.

Acknowledgments

The cooperation of City Engineer E. S. Meckley and City Chemist Harry Krum (now Superintendent of Water) in working out a basis for acceptance of effluents objectionable to public waters is gratefully acknowledged. Also acknowledged is the valued guidance of S. I. Zack, and H. B. Gerber, representing Gannett Fleming Corddry and Carpenter, in solving the immediate problem without prohibitive cost.

Reference

1. "Public Health Service Drinking Water Standards 1946." Reprint No. 2697, *Pub. Health Rep.*, **61**, No. 11 (Mar. 15, 1946).

NEW RECIPIENTS OF HEMISPHERIC SANITARY ENGINEERING AWARDS

The U.S.A. Section of the Inter-American Association of Sanitary Engineering recently announced the bestowal of the Hemispheric Sanitary Engineering Award on Herman G. Baity, Director of Environmental Sanitation, World Health Organization, and former President of the Inter-American Association of Sanitary Engineering; Clarence Sterling, Chief Engineer, Department of Health, Commonwealth of Massachusetts, and former President of the Association; and Thomas P. Browne, of The Permutit Company and the Ionac Company, Ltd., past President of the U.S.A. Section, and at present Vice-President of the Association, for outstanding achievement in the field of sanitary engineering in the Western Hemisphere.

These awards bring the total to nine made during the nine years of existence of the Association. Hereafter, a maximum of one award per year will be made.

WATER CONSERVATION AND WASTES CONTROL AT ELECTRONICS PARK *

By Wallace B. Miller and Vincent deP. Lukas

Respectively, Air Conditioning Engineer, General Electric Company, Syracuse, N. Y., and Sanitary Engineer, General Electric Realty Corp., Schenectady, N. Y.

Electronics Park, headquarters of the Electronics Division of the General Electric Company, closely resembles a university campus with carefully landscaped grounds. The Park, located approximately 5 mi. north of Syracuse, N. Y., covers an area of about 200 acres. Design of the Park required 100 engineers and draftsmen working a full year and preparation of some 500,000 blueprints. Within the Park there are more than 5.5 mi. of paved roads and 3.5 mi. of railroad track. The eight major buildings have a combined floor area of more than 1,500,000 sq. ft. and are almost completely air conditioned for the comfort of the 10,000 employees. The size of the buildings may best be judged by noting that three complete football fields would easily fit into the Radio and Television Department, Building 5. Plans for a 90,000-sq. ft. addition to this building have been completed and construction has started.

At Electronics Park, General Electric develops and manufactures electronic products for a thousand uses. Among the items produced are products ranging in weight from tons to ounces; products for entertainment, comfort, and safety.

From the plant flow television and radio broadcast transmitters and associated studio equipment for stations in hundreds of cities; radio and television sets for millions of homes; radio communication equipment for police and fire departments, taxi, public utilities, and other companies; radar sets for planes, airports, and ships; electronic heaters and controls to aid production in factories; tiny electronic devices, such as the transistor, and huge radar systems for all branches of the armed forces; and sensitive electronic instruments for research laboratories as well as for industrial applications.

The manufacture of these various products would be impossible without an adequate supply of water. Nevertheless, drought conditions have plagued this section of the country for two or three years. As a result, the reservoirs of the state were at only 69 per cent of normal capacity before the 1954 spring rains, which were not sufficient to restore normal levels. On the local scene, the water level of Skaneateles Lake, source of water supply for Syracuse, was 2 or 3 ft. below normal in early summer 1954, despite a wet spring.

The General Electric Company has recognized the importance of water resources of the nation and the need for water conservation. A company-wide program is under way to encourage conservation and sound use of water. It is the aim of the Water Management Program to encourage and aid the individual plants in taking the following steps:

1. Reduce water consumption by making a survey to determine where and how all water is being used; setting realistic water requirements for various operations; recommending the installation of automatic and manual controls to regulate the flow of water as needed; and the carrying out of an

* Presented at 1954 Spring Meeting, New York Sewage and Industrial Wastes Assn.; Syracuse, N. Y.; June 14–15, 1954.

educational program on avoiding waste.

2. Determine where recirculation and re-use of water is economical and to get such practice into operation where applicable.

3. Develop new or substitute sources of supply where they can be economically justified.

4. Provide water softening and deionizing equipment and boiler-water treatment where needed.

Electronics Park is actively participating in this companywide program to reduce water consumption and costs.

Water Consumption and Costs

The source of water supply for Electronics Park is from the Syracuse municipal water system. The average consumption is 1.1 m.g.d., but during hot summer days the consumption will increase to 1.5 m.g.d.

The Park uses water for a variety of purposes, including process water (that is, water used in connection with the manufacture of a product), cooling, boiler make-up water, domestic (including sanitary), and service purposes (that is, water used for automobile and truck washing, laboratories, lawns, and other miscellaneous purposes).

Water usage at the Park is as follows:

Cooling	40.3%
Process	32.5%
Domestic	21.1%
Service	3.4%
Boiler make-up	2.7%
Total	100.0%

It should be noted that cooling water is the most important usage. This is due to the fact that cooling water is essential for many of the processes at the Park and for the air conditioning.

If water conservation—that is, control techniques, recycling, use of private supplies, and water saving devices—was not practiced at Electronics Park the consumption would be about 1,000 m.g. per year, at a cost of more than $150,000. A summary of water consumption and cost for the past five years is given in Table I.

TABLE I.—Water Consumption and Cost at Electronics Park, G. E. Company

Year	Water cons. (m.g.)	Cost ($)
1949	280	$45,150
1950	450	76,725
1951	490	79,325
1952	450	72,575
1953	398	63,725
1954	Decreasing trend still in effect	

Conservation Methods

The desirability of incorporating certain sound water usage steps into the facilities at the Park was realized at the time it was being designed. These water conservation facilities were provided to minimize water requirements and costs. Operating experience has proven the soundness of providing such facilities.

Evaporative Condensers

Air conditioning equipment with a capacity in excess of 5,500 tons of ice per day was installed at Electronics Park to maintain comfort for the employees in the offices, the laboratories, and almost all the manufacturing areas, except in Building 6. Heat removed from these areas cannot be lost, but must be disposed of in some manner. Years ago the most common method of removing the heat was to run water through a condenser and then to the sewer.

At the Park evaporative condensers are used for removing this heat and were installed when the Park was built. Water in the sump of the evaporative condenser is recirculated and sprayed over the hot condenser tubes, a small percentage of this water being evaporated to provide the necessary cooling for the balance of the water. Approximately 1,000 B.t.u. of cooling capacity is obtained from each pound of water evaporated instead of the 20 or 30 B.t.u. that might be obtained by straight water cooling. Some addi-

tional water is used by the evaporative condensers to compensate for drift and constant blowdown to minimize the concentrations of solids in the recirculating water. Water savings amount to approximately 95 per cent of the water that might be used for straight water cooling. If evaporative condensers were not used the water requirements for air conditioning alone would be more than 450 m.g. per year instead of the present usage of only 35 m.g. This sound water practice saves over $65,000 yearly.

After the Park was constructed, plant engineering personnel took additional steps to conserve water.

Private Supply

During initial construction of the Park a spring was found under Building 5. The water flowing from the spring was clear and cool, but extremely hard, and could not be used without expensive treatment. Therefore, the water was diverted into a pond located south of Building 1. As the electrical load increased in the Television Receiver Engineering Laboratory, it became necessary to install 50 tons of additional air conditioning equipment. This was done in 1950, the spring water being used for cooling by using a large volume of water with low temperature rise in the condenser to hold coating of the condenser tubes to a minimum.

If city water had been used instead of spring water, an additional 4 m.g. per year would have been required, and the make-up water to an evaporative condenser, if used, would have been 300,000 gal. per year. Savings at this installation amount to at least $50 yearly assuming recirculation would have been provided, and more than $600 yearly with no conservation.

Refrigeration

Use of mechanical refrigeration has made it possible to conserve additional quantities of cooling water. For example, television picture tubes and other cathode ray tubes must be thoroughly evacuated, and the high vacuum required is best obtained by evacuation at high temperature. This is accomplished by placing the tube on a buggy that travels slowly through an oven where the temperature is carefully controlled to prevent breakage of the glass. Each buggy has a diffusion-type vacuum pump and a head which must be cooled with water at a maximum temperature of 67° F. A typical exhaust area will have 120 such buggies, each requiring 1 g.p.m. of cooling water with a temperature rise of 1½° F. through the cooling system.

As originally designed, city water was circulated through a trough from which pumps on the buggies picked up the cooling water. The water was then circulated through the proper parts and discharged into a second trough from which it flowed to the sewer. Because of the great amount of gas burned in this building the ambient temperature near the roof steel where the water lines run approaches 120° F. This caused undue warming of the water in the large mains at low flow rates, necessitating a heavy flow of water to keep the temperature of the water to the trough within reasonable limits. Mechanical refrigeration placed directly in the trough now does this job, and even though the refrigeration equipment is water cooled, great savings have resulted. The refrigeration equipment can use warmer water to start with and can use this water through a much higher temperature range, so that less than 1/12 as much water is used. Savings on this installation amount to 50 m.g., or $8,000 annually.

Water Conservation Program

During the summer of 1951, personnel from the various departments at Electronics Park initiated a comprehensive drive to incorporate other sound water saving techniques into the

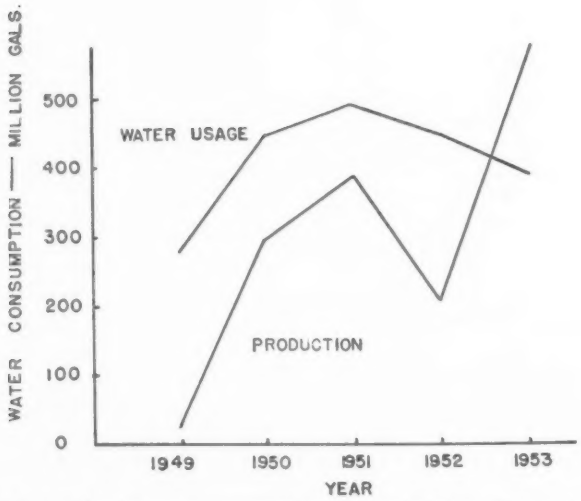

FIGURE 1.—Yearly water consumption and production, Electronics Park.

Water Conservation Program. Considerable progress has been made, resulting in a reduction of more than 150 m.g. of water annually, which resulted in annual savings of $20,000. Production increased about 25 per cent over a 3-year period, yet the water consumption was reduced by 20 per cent.

Figure 1 shows the sharp rise in production based on sales and the continued drop in water consumption. With continued efforts on water conservation, it is estimated that yearly savings will amount to $25,000 in spite of anticipated increases in production.

As a result of this program, several methods of conserving water are being practiced at Electronics Park, including control of consumption, installation of water saving devices and equipment, use of cooling towers, and use of sources of water within the Park. These various methods are described briefly.

Control Techniques

In any industrial establishment, the most obvious methods of conserving water are the elimination of waste and excessive flows. Employees at the Park are probably no different than those elsewhere. They know water costs money because at home they diligently turn off all faucets when not in use and replace washers when the faucets leak. But the moment they enter Electronics Park, their conservative habits seem to reverse.

For example, there are installed a considerable number of resistance welders with water cooled electrodes. At the end of the working day, the operators carefully shut down their machines, but apparently could not be trained to shut off the cooling water.

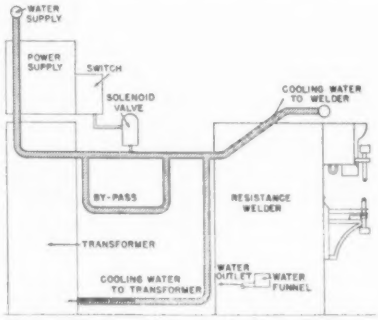

FIGURE 2.—Piping arrangement for resistance welder so water will flow through the machine only while the switch is on.

Electrically-operated solenoid valves were installed in the water lines and tied into the welding machine control circuit in such manner that the cooling water is automatically shut off when the machine is shut down (Figures 2 and 3). This installation saves about 5,000 g.p.d. per welder, or about 50,000 g.p.d. based on the average use of the welders. This procedure is saving at least $2,000 each year.

Automatic flushing is provided for the urinals in all of the men's rooms. A survey showed that flushing intervals varied from 1 min. 30 sec. to 7 min. 40 sec. and that clean and sanitary conditions were maintained at all the various flushing intervals. The needle valves on the water closets were adjusted to flush every 4 to 5 min., saving approximately 8,000 g.p.d. or more than 2.9 m.g. per year. The investigation of seemingly insignificant use of water resulted in reducing water consumption and a yearly saving of $500.

Plating operations require large quantities of water for washing and rinsing the parts. Popular thinking among plating room employees seems to be that the more water used, the better the job. Experience proved that operators often used full line flows regardless of the needs of the operation.

In the plating room in the Radio and Television Department, an orifice was

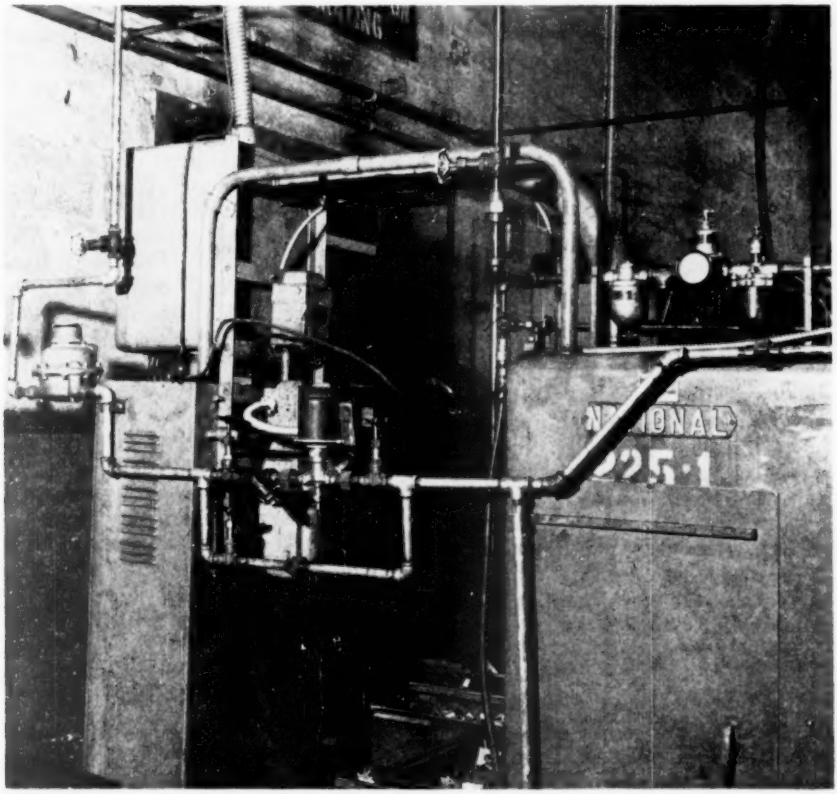

FIGURE 3.—Installation of solenoid valve to shut off cooling water flow automatically when power supply is off.

TABLE II.—Water Conservation in Plating Room, Building 5—Use of Orifices

Operation	Water Usage (g.p.h.)		
	Previous	Present	Saving
(a) Still Plating Area			
1st rinse, hot	650	50	600
2nd rinse	840	120	720
3rd rinse	840	120	720
Cold rinse after chromic acid	800	120	680
Barrell plater rinse	850	120	730
Cold rinse before cyanide	800	120	680
Cold rinse before muriatic	800	120	680
Cold rinse before Clepo cleaning	850	120	730
Cold rinse before C-75 cleaning	850	120	730
Cold rinse before oil dip	650	50	600
Cold rinse before cyanide	850	120	730
(b) Automatic Plater			
1st hot rinse after Clepo	400	120	280
2nd hot rinse after Clepo	400	120	280
1st cold rinse before cyanide	1,140	720	420
2nd cold rinse before cyanide	1,140	720	420
1st cold rinse after cyanide	1,140	720	420
2nd cold rinse after cyanide	1,140	720	420
Rinse after chromic acid	1,140	720	420
1st rinse after Irridite	1,140	720	420
2nd rinse after Irridite	1,140	720	420
Hot rinse before hot blast	100	25	75
Total	17,660	6,485	11,175

placed in the water line to one of the rinse tanks on a trial basis. This orifice reduced the flow from 840 g.p.h. to 120 g.p.h. even with the hand valve fully opened, and without impairing the rinsing operation. Results were so encouraging that fixed orifices were installed in the water lines to the rinse tanks for the entire plating room at a cost of $720, and a water savings of more than 10,000 g.p.h. resulted (Table II). The cost of all material and labor for the installation was paid off within two months. This technique was used in plating rooms of other departments. Total water conserved was around 45 m.g., or a cost reduction of $7,200 per year.

Water Saving Devices and Equipment

There are several small self-contained air conditioning units, climatic chambers, and industrial refrigeration units located at widely scattered points which were installed over a period of years where the recirculation of cooling water or use of evaporative condensers was impractical or uneconomical. It therefore became necessary to use city water to condense the refrigerant for these installations, but water regulating valves were installed to regulate the flow of water through the condensers. These water regulating valves are automatic devices which shut off all water when not required, and vary the flow of water in accordance with the load on the system.

Another water saving device in use is a water shutoff valve for evaporative condensers, which require a constant source of make-up water during operation. This make-up water must necessarily come from the city water mains and is controlled by a float valve in the evaporative condenser sump. Continuous throttling of these valves results in excessive maintenance and waste of water due to wire drawing of the valve seats. Auxiliary air-operated shutoff valves were installed and connected to the control circuit in such manner as to completely shut off the supply of water when the evaporative condenser is not operating. Wire drawing is no problem with these valves because they do not throttle. Water savings in Building 5 alone amounted to 25,000 g.p.d. The installation of shutoff valves on evaporative condensers throughout the plant conserved a total of 24 m.g. of water per year at an annual savings of $4,000.

Among other water saving devices used at Electronics Park is the Water Economizer, manufactured and sold by the General Electric Company. This is used on induction heaters and similar equipment where large volumes of cooling water are required with a very low temperature rise in the water, thereby making use of city water costly. The cooling water is merely recirculated through a storage tank in which the temperature is controlled by introducing city water through a thermostatically controlled valve. Surplus water overflows to the sewer.

Cooling Tower

In 1951, a 1,250-hp., 6,000-c.f.m., 100-p.s.i. air compressor was installed to meet expanding compressed air requirements. This compressor required cooling water for after-cooling, interstage cooling, and cylinder cooling. At full load the cooling-water requirements would be 215 g.p.m. of 70° F. city water or 300 g.p.m. of 85° F. recirculated water. The obvious solution was to install a cooling tower, which cost only $5,300 installed. This tower saved approximately 190,000 g.p.d. With a water cost of $0.16 per 1,000 gal. the cost of the cooling tower was paid off in a short time. Yearly savings now amount to $6,750.

One additional economy was affected in this particular installation. The boiler house office is air conditioned by one of the small water-cooled self-contained air conditioners referred to previously. Since the cooling tower is located near the boiler house, all of the city water flowing through this condenser drains into the cooling tower, thereby supplying nearly 90 per cent of the necessary make-up water.

Another cooling tower, serving a 25-ton industrial air conditioning system, located inside a manufacturing building.

Other Methods

At Building 7, large quantities of water from the footing tile drains discharge into a sump. This water is clear, cool, and soft, but the supply is variable, depending to a great extent upon seasonal rainfall. It used to be pumped into a storm sewer, but is now used for condenser cooling water for climatic chambers, and is supplemented with city water as required. Average water flow from the drain tiles is approximately 130 g.p.m., which results in a substantial saving in a year. Annual usage from this source amounts to approximately 30 m.g. with a saving of $4,800.

In Building 5, where all General Electric television sets are manufactured, there is an excellent example of what can be accomplished to eliminate waste and excessive flows of water. A recording and integrating water meter was installed in the 10-in. water main to the building. The meter charts provided valuable data and helped to determine times flows appeared to be excessive. With this information, it was possible to eliminate waste of water. Accomplishments can be seen by comparison of typical meter charts (Figure 4) taken before and after conservation measures were installed. It should be noted that, on the average, flows were reduced 100 g.p.m., whereas peak demands were reduced as much as 150 g.p.m. Moreover, this reduction was made in only one of many buildings.

Summary

Results to date have been gratifying and a substantial reduction in water consumption was achieved during a period of increased production and employment. Accomplishments to date are given in Table III.

Future Efforts

In addition to the conservation steps already taken, many additional ones

TABLE III.—Summary of Water Conservation at Electronics Park

Practice	Water Use (m.g./yr.)			Yearly Saving ($)
	Without Conservation	With Conservation	Difference	
Initial construction:				
Evaporative condensers	450	35	415	66,000
1950 program to present:				
Use of private supplies	34	0	34	
In-line exhaust machines	62	12	50	
Welders	27	14.5	12.5	
Automatic flushing	40	37.1	2.9	
Plating room	75	30	45	
Shutoff valves	—	Est.	16	
Cooling tower	79	7	72	
Sub-Total			232.4	37,000
Total			647.4	103,000

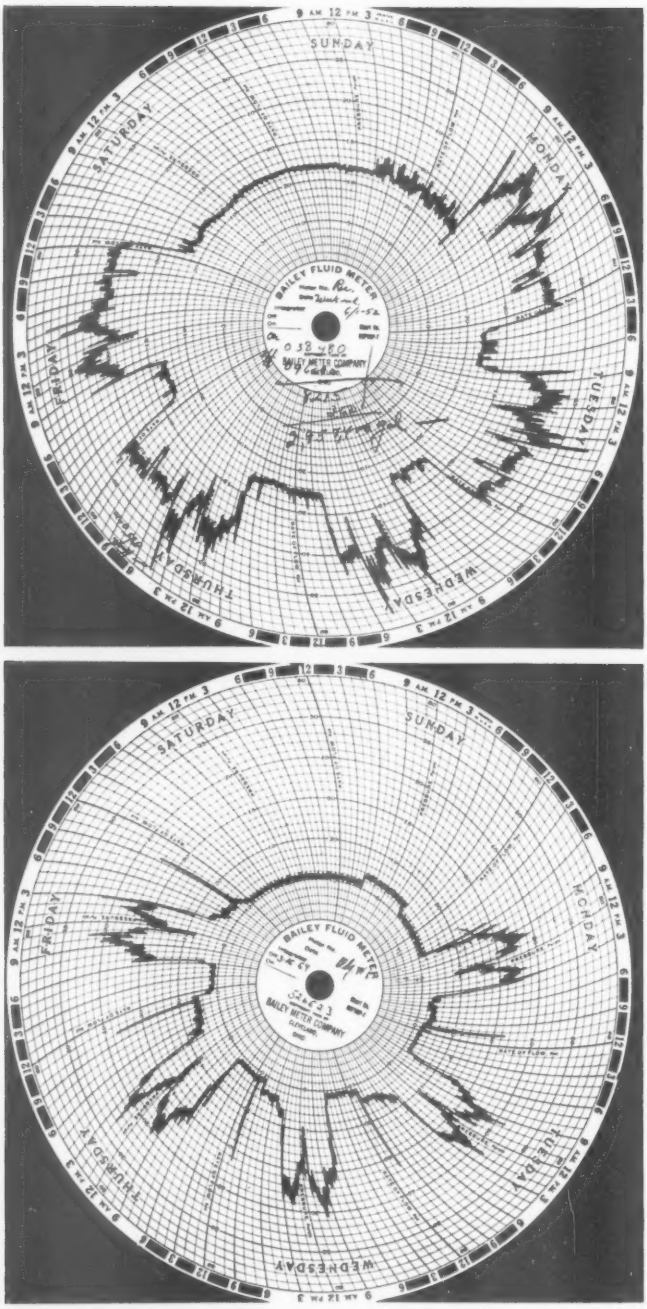

FIGURE 4.—Typical weekly water meter record for Building 5 before (top) and after conservation practices were put into effect.

are planned. These include, among others:

1. Metering of flows to all buildings. Recording and integrating meters have been ordered for Buildings 6 and 7. Temporary integrating meters have been installed for several other buildings.
2. Routine checking of water consumption.
3. Installation of a cooling tower for the natural gas compressors, which are currently using 11,000 g.p.d. of water.
4. Installation of a number of small cooling towers properly located on the manufacturing building roofs to save most of the water now being used for condenser cooling, for equipment used for process-water cooling, and the scattered self-contained air conditioners.
5. Connect the water cooling for fan bearings to the cooling tower at the power house. At present, 10 g.p.m. are required for each boiler in operation.

This paper is mainly concerned with water management, but the field of waste control is so closely related that the latter area also should be covered briefly.

Process Wastes

Sanitary sewage and industrial wastes are discharged into the Ley Creek (Syracuse) Sanitary District sewer. These wastes have created no particular problems at the Ley Creek treatment plant. Occasionally, personnel from that plant have requested that the wastes at the Park be checked for certain objectionable characteristics. As a result of requests of this type, plant personnel have evaluated the waste discharges and been able to eliminate certain objectionable materials.

One of the most extensive of these surveys was completed in April 1951. This was a complete definition survey, which consisted of sampling and measuring the volume of the plant discharge every 15 min. over a normal operating week. These individual samples were combined into composite samples for comprehensive analyses. This survey indicated that as a general rule the plant effluent remained within proper accepted practice limits for discharge into a municipal sewer system. Efforts have been under way since this survey to round off the occasional peaks when acid or solids concentrations might exceed accepted practice levels.

Uncontaminated cooling water is discharged into storm sewers leading to nearby Bloody Creek.

The water management steps being practiced at Electronics Park have been directly beneficial in controlling the waste problem. This approach to waste control is not only effective at this plant, but has application to most industrial plants of any magnitude. Direct industrial waste control benefits resulting from water conservation as outlined hereafter have application to Electronics Park and other plants.

Conservation and sound usage of water reduces the volume of process wastes which must be handled. This simplifies the segregation problem. Such reduction in volume reduces the cost of treatment facilities which must be provided, if any, or minimizes the sewer service charge which must be paid to the city for municipal sewer discharge. The reduction in the volume of waste entering a municipal sewer is sometimes directed by the city and in some cases clean cooling water will not be accepted.

Where treatment is necessary, control of such treatment is for the most part simplified if the volume of the material is reduced and by this same means the concentration increased. The quantity of chemicals required for satisfactory treatment is generally slightly reduced if the waste load in question can be concentrated into a smaller volume.

Conclusion

Experience at Electronics Park has indicated the industrial water conservation program to be sound. Water officials of Syracuse announced on June 9, 1954, that lower consumption has placed the city in its best condition in recent years regarding water supply. The expanding water management program in effect at the Park is permitting this plant to do its share in conserving a valuable natural resource, as well as reducing water costs by more than $100,000 per year, while at the same time realizing the additional benefit of minimizing the industrial wastes from the plant.

TNT WASTES TREATMENT REPORT

Objectionable red coloring of streams near TNT manufacturing plants may be largely eliminated as a result of a two-year research on the problem. A summary of the study was presented by Professors Gail P. Edwards and William T. Ingram, College of Engineering, New York University, during the annual convention of the American Society of Civil Engineers, held in New York City, October 18–22, 1954. The project was carried out under the sponsorship of the office of the Surgeon General, U. S. Army.

The sellite waste produced by the TNT manufacturing process presents local problems because of the deep red color it imparts to the receiving waters. It also "sharpens" the taste of such waters when they are chlorinated for drinking purposes, and in high enough concentrations could be toxic. The color is very resistant to biological and chemical attack. Some of the most effective treatments—for example, adsorption on clays and activated carbon—are ruled out because of high cost.

Slightly more than 1 gal. of waste liquid results from each pound of TNT produced. As the waste stands, the color becomes stronger and more difficult to remove.

The treatment method involves removal of more than 90 per cent of the color by chlorination at 9,000 p.p.m. in a tower packed with ceramic media. Treatment with chlorine gas was found to be preferable to addition of hypochlorite solution. The resulting acidity is neutralized with caustic. The remaining color is a yellow similar to that found in natural waters and is virtually non-objectionable.

Operating costs of the system of eliminating the sellite color are estimated to be less than $0.25 per 100 lb. of TNT, about four-fifths as much as removal by evaporation.

SOUTHLAND PAPER MILLS WASTE TREATMENT AND DISPOSAL

By Fred W. Bishop and J. W. Wilson

Respectively, Chief Chemist, Southland Paper Mills, Inc., Lufkin, Tex., and District Engineer, Bureau of Sanitary Engineering, Texas State Department of Health

With the rapid expansion of industry in Texas, the rivers and streams have become one of the most valuable resources from the standpoint of both water supply and waste disposal. The rapid growth of pulp and paper operations is probably typical. Recognizing initially that its liquid waste would be entering a small receiving stream, the Southland Paper Mills organization has always followed the policy of working very closely with the State Department of Health and the Game and Fish Commission by keeping them informed of all activities and soliciting their recommendations in the design of processes for the reduction of pollutional loads.

The total mill effluent from Southland Paper Mills is finally discharged into the Angelina River, which has a normal winter flow of 1,000 c.f.s. and long periods of low flow during the summer (on occasion as little as 10 c.f.s.) Since 1948 the volume of this effluent has been in the vicinity of 18 c.f.s. With a small amount of treatment, the river at winter flows can normally absorb this waste; the bulk of treatment activities, therefore, is carried out at a time to anticipate the low summer flow.

Considering the small size of the mill for the first few years, waste disposal presented no real problem. In the early days the mill operated one newsprint paper machine and a groundwood pulping plant to produce the requirements for the machine. The kraft pulp requirements were purchased from another mill in the vicinity. This excluded the high pollutional loads from kraft mill operation normally found in southern mill wastes.

With the beginning of construction of a kraft mill and bleach plant, the waste disposal from this operation was recognized as being serious. Following the work of many other mills, the Technical Service Department explored the economies of almost every conceivable type of chemical treatment for the removal of B.O.D. using, primarily, coagulating materials. Capital cost of equipment and operating costs in the use of any of these processes were prohibitive economically.

Biological Treatment Studies

Biological treatment of kraft mill waste was never considered to be very effective in the past where oxidation lagoons were employed for impounding or storage. The Southland operation, where such waste would be mixed with groundwood mill effluent, might have a better chance of success because the groundwood effluent contains the water-soluble constituents of wood which are primarily reducing sugars. It was felt that the sugars would act as a primary source of food for the bacteria to give these organisms impetus in their attack on the stronger kraft mill wastes.

This work was initiated in the laboratory by setting up storage crocks on the separate and total mill effluents to determine the extent of B.O.D. reduction as related to time. It was soon observed that combined total mill effluent exhibited the most rapid rate of decomposition, with the time requirement varying from 15 to 20 days.

This type of work was continued in the laboratory under controlled conditions of supplemental seeding and feeding under both aerobic and anaerobic conditions. To substantiate the fact that the decomposition was bacteriological in nature, the material was set up under sterile conditions after it had been filtered through a Seitz filter. This work proved that B.O.D. reduction was due to the action of microorganisms; further work indicated that little, if any, benefit was derived from the action of enzymes.

The Pilot Plant

Pilot ponds of known volumes were constructed and fed with total mill effluent at controlled rates to approximate 10, 15, 20, and 25 days throughput detention periods. This work was instrumental in the sizing of large ponds whereby extensive B.O.D. reductions on total mill effluent could be anticipated employing only the bacteria that were native to the air, soil, and wastes.

Accordingly, two 50-acre ponds were constructed in series below the mill outfall in such a manner that the natural topography could be employed to the best advantage by merely constructing dams across ravines. An overflow tower (Figure 1) was constructed near each dam and conduits were installed beneath the dams to carry the flow from one pond to the next or to the natural stream bed from the last. Large spillways were constructed at one end of each dam to handle the runoff from flash floods. The average depth of the ponds is approximately 5 ft., and the throughput detention time was in excess of 20 days initially.

Lagoon Operation

The summer of 1946 represented the first full season of operation using this system. With effluent flow of nearly 8 m.g.d. and the B.O.D. in excess of 200 p.pm., the load from the mill represented nearly 7 tons of B.O.D. per day. After going through the ponds and flowing down approximately 8 mi. of normally dry creek bed, the waste entered the river at a strength of about 1.3 tons per day. Throughout this period extremely good river conditions were experienced downstream, particularly when compared with the previous year's operation with comparable waste

FIGURE 1.—The second of two 50-acre ponds comprising the oxidation lagoon system, showing the dam for the first pond (background) and the overflow tower and access catwalk of the second pond (left).

from the mill. The Departments of Sanitary Engineering and of Bacteriology of Texas A & M worked closely with the mill in the evolution of this lagooning process and were able to substantiate the microbiology of the system.

It should be pointed out that the size of these ponds was such that the sedimentation of all suspended materials (mainly fibrous in nature) occurred at the inlet end of the first pond. This constituted the complete removal of all suspended material during the critical season of low river flows and indicated another problem that would eventually require additional consideration. This settled fiber would decompose naturally and gasify to the extent that large portions of the sludge would rise to the surface and float. After the pond was dumped to the river at the end of a season, the sludge would dry and float again when the pond was filled the following season. After a couple of years of operation, more than one-half of the surface of the pond was covered with floating sludge.

The accumulation of settled and floating sludge in the first pond would eventually reduce retention time materially, and the ensuing decomposition would contribute more pollutional load. Anticipating additional expansion, it was decided to install a presedimentation pond ahead of this first pond for the accumulation of suspended fiber. This pond was constructed with gradually sloping sides to facilitate its cleaning during the winter months by flushing into the natural stream bed and on to the river bottom during periods of flood flow. In the following years of operation, this pond proved to be too small for the amount of suspended material leaving the mill during the seasonal operation of each year. Part of this was due to the fact that the best efforts to clean during flood flow probably did not exceed 70 per cent. The upper end of the first large pond has continued to fill. Furthermore, the sludge deposits from this dumping were spread out over the river bottom and the drainage from this in sloughs contributed considerable pollutional load to the river as it started fast summer flow reductions.

Mill Expansion

Shortly after the installation of the presedimentation pond the mill started operation of greatly expanded production facilities. This involved a 100 per cent increase in newsprint capacity and a smaller increase in kraft pulp mill and bleach plant productions. Although the production increases were small in the kraft pulp mill, they overloaded some of the washing and recovery equipment as far as their design specifications were concerned, and larger losses of kraft mill black liquor went to the sewer. In spite of this, the operation is considered to be very efficient, but the pollutional load increased accordingly. The total waste discharge from the mill was nearly 12 m.g.d., with an average B.O.D. of 350 p.p.m. Accordingly, the pollutional load increased to nearly 18 tons per day, and under the best conditions of pond operation an average load of 4 tons per day was discharged to the river.

Activated Sludge Process

The efforts of the technical staff and regional resident engineers of the National Council for Stream Improvement contributed considerably to the success of the Southland lagooning operations and focussed attention in the southern region on the evolution of an accelerated process for the decomposition of kraft mill wastes. In this region that waste constitutes the strongest single weighted contributor of pollution load. The final process as carried through the pilot-plant stage at a southern mill is a modification of the activated sludge process used in

the treatment of sanitary sewage. The pilot-plant work indicated further that the discharge of treated waste from this process would greatly accelerate the activity when mixed with other wastes going to oxidation lagoons.

At Southland this was followed with great interest because the oxidation lagoons were overloaded and the mill was anxious to correct the situation that had arisen as a result of expansion. Naturally, the Council was anxious to see the process applied to a mill-scale operation. Equipment available in this plant for the process included a 206,000-gal. concrete tank (10 by 11 by 270 ft.) and a 120,000-gal. clarifier which could be pressed into this service. With the purchase of a blower and some extensive piping changes, the process was put into operation actually before the pilot-plant work was completed.

Basically, the process is one of perpetuating the species of acclimated bacteria by supplying the necessary requirements of food, nitrogen, and air and by generally maintaining these healthful environmental conditions. The food originates from the organic matter in the waste, the nitrogen is supplied from ammonia, and oxygen is supplied by diffusing low-pressure air through the total mixture for several hours. Under these conditions the microorganisms devour the organic compounds and derive their energy by the oxidation of these, thus reducing the amount of organics and, correspondingly, the B.O.D. of the effluent. Following aeration, the total effluent is clarified for the collection, concentration, and recirculation of seed sludge.

The Process at Southland

The system at Southland was seeded initially with 10,000 gal. of sanitary sewage sludge, and with excess air the flow of raw waste was started slowly and increased gradually. Efficiencies during the first few months of operation were not too good, but after the activated sludge had become acclimated the efficiencies improved. With a raw waste flow of 500 to 600 g.p.m., the system was subjected to extremes of waste concentration varying from 200 to 500 p.p.m. B.O.D. At low levels of B.O.D. the reduction is often as much as 85 per cent, but with incoming B.O.D. of 500 p.p.m. a reduction of 60 per cent is more general. The B.O.D. level stays relatively constant for a period of two or three weeks, with changes occurring gradually to move it from one level to another prior to each period of sustained strength.

Although the process was started in the summer of 1952, the real benefit of its operation was realized during the summer of 1953, when average efficiencies of 75 per cent were recorded and a good portion of this effluent was going to the oxidation lagoons. During that year, with a waste discharge of 18 tons of B.O.D. per day it was entering the river at approximately 1.5 tons per day, approximating the pollution load prior to the expansion.

Equipment Improvement

To bring this operation up to date, it should be mentioned that the original clarifier used in the process was not of the proper design, and the concentration of sludge solids in the underflow was no more than 6,000 p.p.m., necessitating a recirculated volume of 400 g.p.m. to maintain a concentration of 2,500 p.p.m. of sludge in the aerator. Recognizing the effect of this volume on the detention period in the aerator, it was decided that a properly designed clarifier should be purchased for this phase of the operation. Accordingly, a radial flow clarifier incorporating the principles of sludge thickening design was installed and placed in operation in February 1954. This clarifier has an underflow concentration varying from 15,000 to 20,000 p.p.m. and a flow of 80 g.p.m. will suffice at these concentrations to main-

tain the required solids concentration in the aerator. This and other changes have increased the detention period at that point from 3 to approximately 5 hr. The system as it presently exists requires a minimum of attention, with most of the process observation being performed during the daytime and occasional checks made by shift personnel during the night. Figure 2 shows the clarifier and aerator located on the mill grounds.

Operation

In the operation of any activated sludge process there is always considerable concern about losing the activity of the sludge or of actually killing the bacteria. Throughout this mill-scale operation there have been many occasions when the organisms have been subjected to rather drastic surges of waste concentration. Generally they will show some loss in effectiveness, but recovery will occur in a very few days. Due to bearing failure on the blower, there have been occasions when the sludge was without air for periods of 36 hr. During a period of three weeks when the kraft pulp mill was down, seed organisms were kept alive by feeding blackstrap molasses to the system in the presence of the other activating requirements. This source of food was added at a rate of approximately 25 per cent of the normal food which would be derived from waste in operation. After resuming pulp mill operation, the waste load was gradually increased to maximum flow over a period of about five days. It appears that once the species are established and acclimated, they become very hardy as long as the operation is conducted to avoid extreme conditions.

With the new clarifier in operation and the system now considered to be of proper design throughout, it is expected that the 1954 summer operation will be better even than that of the previous year. None of the clarified effluent from this system will be reused in the mill; all of it will be going to the oxidation lagoons at all times in such a manner that the full beneficial contribution of this effluent to the lagoons will be realized throughout the season.

FIGURE 2.—Radial design clarifier (left center) and aeration tank (running diagonally across center) of pulp mill wastes treatment plant.

In-Plant Water Conservation

Contributing to the high strength of total mill effluent is the fact that the fresh-water supply to this mill is rather limited and expensive, as it all originates from deep wells. The different departments operate on what is considered to be the minimum of fresh-water requirements for the processing of a ton of product in each. Extensive in-plant water conservation practices and reclaiming for re-use are employed. This includes the collection of nearly all waters used for cooling purposes on bearings, in drums, etc., for recirculation to the cooling towers and then to the supply system. This collection alone amounts to more than 2 m.g.d. Waste water from the machines and groundwood mill operation is clarified for the removal of suspended fibrous material. This operation makes up to 1,000 g.p.m. available for re-use in the kraft pulp mill, replacing fresh-water requirements.

Irrigation Project

Of more recent interest is an irrigation study that has been set up at the request of the State Health Department to determine the extent, if any, of soil damage in the use of the treated effluent as a source of irrigation water on crops. This has been set up by clearing and fencing two 5-acre plots which have been planted with Kobe lespedeza with the maximum application of fertilizer requirements. One of these plots is a loose sandy soil; the other is a relatively tight typical East Texas bottomland soil. Sprinkler-type irrigation equipment was purchased and will be used to irrigate only half of each plot, with the unirrigated portion of each used as a control in the determination of yields. With the moisture requirements being satisfied on the irrigated portions, it is anticipated that two, or possibly three cuttings of lespedeza can be made during each growing season. The crop of weeds and grasses has been so thick during the first year and the initial seeding was so late that the expectations may not be realized, but it is hoped that denser stands of the planted crops will be possible in subsequent years. This is a long-range project with an anticipated duration of five to ten years in the interest of determining soil damage if it should occur.

All of this is an example of an industry that recognized in the early stages that a small receiving stream would be subjected to ever-increasing pollutional loads from a rapidly expanding operation. The continuous program of research for new and improved methods of waste treatment has enabled this industry to expand the plant facilities without increasing the pollution load on the receiving stream. The good results to date exemplify what can be accomplished when all available technical knowledge and ingenuity are applied to the problem within the bounds of economic justification.

THE OPERATOR'S CORNER

CONDUCTED BY HERBERT P. ORLAND

DETECTION OF SHOCK LOADS RESULTING FROM INDUSTRIAL WASTES *

BY W. D. HATFIELD

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There is a definite place for two types of analyses in the operation of a sewage or industrial wastes treatment plant. For the over-all assessment of process loadings, efficiencies, and records of accomplishments, standard methods or other methods of accurate chemical or biological analysis are required. Ordinarily these are the standard methods for total, dissolved, and suspended solids; dissolved oxygen and biochemical oxygen demand; chemical oxygen consumed; nitrates; and pH. In some cases specialized standard procedures may be desirable. These procedures are usually applied to composited samples which represent a 24-hr. period, although occasionally an 8-hr. or shift sample is used.

It is important to protect a sewage or industrial wastes treatment plant from shock loads due to strong acids, alkalies, cyanides, heavy metals, organic loads, and solids. Such shock loads, if occurring only one or two times a day, often will not be detected when diluted with 22 or 23 volumes of normal wastes in making up the 24-hr. composite. The pH might be lowered from 7.4 to 7.0 by one acid sample of pH 3.0, or the B.O.D. increased from 200 p.p.m. to 230 p.p.m. by one hourly sample of 1,000 p.p.m. These average variations are so near to the daily fluctuations that they could go unnoticed unless the pH-3.0 shock killed the activated sludge or the 1,000-p.p.m. B.O.D. shock (due to sugar) has caused "unexplainable" bulking of the sludge.

Sampling and Tests

Procedures for collection and testing should be developed to detect the so-called "shots" or "shock loads" and which will tell the hour in which they arrived at the treatment plant. Obviously, recording apparatus which would give a record of the pH, oxidation-reduction potential, chemical oxygen consumed, dissolved oxygen, B.O.D., etc., on a timed chart would be ideal. There are a few specialized cases, such as pH recorders, with which this is possible, but only at a relatively high cost and constant maintenance. The next best is a systematic collection of hourly (or more frequent, if necessary) grab samples which are not poured together in a composite bottle, but which are labeled and kept in a cooler for inspection and/or analysis the following morning.

Because of the large industrial load which the Decatur, Ill., plant receives, the practice of collecting two 4-oz. grab

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samples of the sewage each hour was established many years ago. One sample is poured into a large-mouth 2-qt. mason jar for compositing by 8-hr. shifts; the second is capped with a Bakelite screw cap and preserved as an hourly grab sample. Both composite and hourly samples are partially submerged in a soda bottle cooler at 3° to 4° C. for preservation. The primary and secondary effluents are collected only for compositing by shifts, there being no extra grab samples taken. The shift samples are proportionately composited into a 24-hr. composite for analysis. These shift samples are kept separate chiefly to catch the occasional error, due to mixed samples, which will occur occasionally in the best regulated plants.

Thus, each morning the chemist has a row of 24 4-oz. samples representing the hours from 8 AM one day to 7 AM the following day. Visual inspection of the bottles indicates those with unusual colors, heavy sediment, high turbidity, and the presence of an oil sleek. (The 4-oz. bottles are of a wide-mouth type so that an oil sleek is visible.)

Rapid Analysis (pH)

With the aid of pH electrodes having 30-in. leads the 24 pH values are determined in about 5 min. No attempt is made to determine these pH's more accurately than to about the nearest 0.1. What is being sought are the samples whose pH value varies from the normal range of plant values. Such a series of tests often tells, for example, that at 10 AM a certain industry dumped an alkaline boil-out of one of their evaporators, which they are supposed to recover and keep out of the sewer. Also, the 11 PM sample with a pH of 3.0 indicates a slug of acid. A qualitative test shows if it is muriatic or sulfuric acid. Experience indicates which industry is likely to dump muriatic acid from regeneration of a large demineralizing plant and which industry is likely to dump a sulfuric acid pickle liquor vat.

It is rather satisfying to be able to call an industry on the telephone and ask if they knew they lost 500 or 1,000 lb. of muriatic acid last night at about a certain hour—say 9 PM—which would arrive at the plant at 11 PM. The usual answer is: "We don't think so, but we certainly don't want to lose any such amount as that. We will check up and see." When this has happened two or three times and they find that you know what you are talking about, you will gain their confidence and a way will be found to fix, neutralize, or recover the offending losses.

Heavy Metals

Another easy loss to detect is chromium, which gives a definite yellow color to the sewage in amounts as low as 1.5 to 2.0 p.p.m. and can be detected by spot-plate tests in much less amounts in the presence of 100 p.p.m. of many heavy metals with diphenylcarbazide (1). Iron is usually visible to the eye due to hydrolysis into colloidal ferric hydroxide, which gives the sample a yellowish-brown cast. A spot-plate test with 1,10-phenanthroline will detect 1 p.p.m. Fe in the presence of 100 p.p.m. of other heavy metals (1).

Other tests for determining cadmium, copper, lead, manganese, nickel, and zinc rapidly are available (1). Cyanides may be detected in small samples by the pyridine-pyrazolone (2) or the pyridine-benzidine (3) methods. Many of the spot-plate methods are made semi-quantitative by using standard solutions and comparing the color in the spot-plate depressions.

Sugar-Carbohydrate Group

One is not interested in the accurate determination of any of the suspected elements, but is looking for "shots," "losses," or "shock concentrations" of say 1, 10, 20, 50, 100, or even 10,000 p.p.m. This is illustrated by a test for

the sugar-carbohydrate group which has been found most helpful in detecting certain losses from the corn products manufacturing processes at Decatur. The test is not specific, but reacts to give a yellow to red color with sugars, starches, dextroses, etc., in quantities of from 20 to about 10,000 p.p.m., where charring occurs. The scale of color comparison is by memory and reads about as follows: 0, 50, 100, 200, 500, 800, 1,000, 2,000 5,000, and charring at 10,000 p.p.m. or greater.

The method, which is simple, is as follows. Add 2 drops of sodium-cresol-oleate solution (6.5 g. sodium oleate and 12.5 g. cresol dissolved in 100 ml. of distilled water) to each of 24 test tubes arranged in a rack. With a medicine dropper, add 1 ml. (1 bulb full) of each of the 24 hourly samples and then add 2 ml. of conc. H_2SO_4 from a burette and shake each tube thoroughly. Read the colors in about 5 min., using known sugars or carbohydrate as standards for training the eye.

This test has been of inestimable value in checking large losses of evaporation pan entrainment at the glucose refinery, sugar losses from zeolite clarification of syrups, and leaking tubes in evaporators or other apparatus. Certain very red or pink colors indicate losses of alcohols, aldehydes, and ketones from fermentation of steep water in the process.

Chlorine Demand Test

Certain types of organic and also inorganic wastes have a strong avidity for chlorine; a simple chlorine demand test which can be run on the 24 hourly samples is valuable. After removing a few ml. for the previously mentioned spot tests, there remains in each 4-oz. bottle about 110 ml. of sample. The 24 samples are acidified serially in the original 4-oz. bottles with 0.5 ml. each of conc. H_2SO_4 from a burette, then stirred with a plunger-type stirring rod after adding two drops of methyl orange indicator. A 25-ml. burette is filled with standard sodium hypochlorite solution (20 to 25 ml. Zonite per liter of distilled water adjusted so that 1 ml. is equivalent to 10 p.p.m. chlorine demand when titrating a 110-ml. sample). Then each sample is titrated 1 ml. at a time until the pink color is nearly destroyed, then with 0.5-ml. additions until the pink color is destroyed. In this way chlorine demands of 10, 20, 25, 30, 35, etc., p.p.m. are obtained on all 24 samples in about 20 min. The Decatur sewage will usually have a chlorine demand of 10 to 20 p.p.m., but certain process-water losses will run this to as high as 70 or 80 p.p.m. on rare occasions.

The foregoing tests are only suggestive of what may be developed in the way of quick semi-quantitative methods that may be used to spot relatively high losses and the probable hour in which they occurred. This information will be of value to the operator and also to the industry which is experiencing the loss.

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REVIEW OF EXPERIENCE WITH FROTH FORMATION IN SEWAGE TREATMENT PLANTS

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During the last few years various sewage plant managers in the United States and Great Britain have pointed to the increasing occurrence of frothing in the aeration tanks of activated sludge plants. This is a nuisance, because the froth is blown out and consequently the walls of the tanks are soiled with a greasy mass and the sidewalks become slippery. It is not surprising that this frothing is attributed to the increasing use of synthetic detergents for domestic purposes, as a result of which these substances find their way into the sewage.

The trouble was first reported in 1947 by the Mt. Penn (Pa.) plant (1). This report was followed by many others.

Occurrence of Frothing

According to McNicholas (2), frothing seems peculiar to the diffused air process; it has not been observed by him in mechanical or brush aeration plants. Moreover, only when a plant is in good condition does frothing occur. Heavily loaded units do not froth.

Frothing increases as the sewage goes through the aerator; it begins at the outlet end of aeration tanks and gradually develops towards the inlet end. Froth is not often observed in the first bays of the aeration tanks (2)(3)(4)(5)(6). Bloodgood (7), however, has observed the opposite phenomenon; namely, particularly bad frothing at the inlet end, decreasing toward the effluent end. This seeming contradiction is explained by an observation by Wells (5), who points to the occurrence of two different kinds of froth: one due to a low solids content in the mixed liquor and formed on the effluent side of the aeration tank; the other light, transparent, fragile, and formed on the influent side of the aeration tank at a high syndets content.

Froth is usually most voluminous from late evening to early morning, when the actual aeration period is above the average and when the general sewage strength and also the soap and syndets concentrations are at a minimum (8)(2). The froth decreases or disappears in the afternoon (3)(9). According to Reed (7), the reduced organic load of the aeration tanks seems to increase the tendency for froth to form. The dissolved oxygen content in the aeration tank, the rates of air application, and the aeration time are probably also of importance for froth formation (5)(6)(9)(10).

After the weekly washday, froth generally increases, presumably because increased amounts of detergents are present (2)(11). Bright sunlight appears to have a depressing effect on the froth and breaks it (3)(2). The froth also was found to have a high content of coliforms, total bacteria (12)(13), grease, and detergents (14), as well as chironomid larvae (2).

Cause of Froth Formation

The foregoing shows that froth can be formed in sewage treatment plants under widely divergent conditions. Considering the enormously increased consumption of syndets since World War II and the much greater frequency of complaints of abnormal and troublesome froth formation in sewage treatment plants, it looks as if syndets may be one of the major causes. There are no doubt other causes of froth formation, but the connection between the

various factors is still imperfectly understood. At one time froth is formed and at another time it is not, under apparently the same conditions. For example, Edwards (3) remarks: "With four batteries in one plant one may froth and the others may not. Each receives exactly the same sewage, but other conditions in each of the batteries may be different."

Whether or not froth is formed is probably determined by the nature of the sewage, the type of plant, and the operating conditions. It may form even when the sewage contains hardly any syndets.

Montgomery (7) observed froth formation in trickling filter drains long before detergents began to be widely used. So did Edwards (3) in aeration tanks in 1941.

According to Eckenfelder (8), frothing is more frequently encountered at a certain stage of oxidative purification by plain aeration of the activated sludge than in the presence of detergents in their present concentration. The foaming zone is marked by a high alkalinity (pH 8.2) and represents the latter part of the carbonaceous oxidation.

Various investigators believe that froth formation in aeration tanks is caused by low suspended solids content in the mixed liquor (Table I). By adjusting the solids content in the aeration tank to the level necessary for the particular conditions of the plant, frothing can be prevented, even with high concentrations of syndets in the mixed liquor (5)(6)(4)(15). The findings in this connection suggest that they hold for all types of anionic detergents; that is, both for the alkyl sulfate (Teepol) and the alkylaryl sulfonate type (Tide is a mixture of alkyl sulfate and alkylaryl sulfonate), in spite of the fact that these two types behave differently as regards biological conversion and oxidation. Alkyl sulfates are easily converted biologically and will therefore be practically absent from the effluent of the aeration tank, unlike the alkylaryl sulfonates, which are more difficult to break down. No data have yet been published on the behavior of non-ionic detergents, which are very difficult to attack biologically, as regards frothing.

Walther (7), Wells (5), and Hurley (15) point out that frothing is always observed when putting an activated sludge plant into operation. The plant will invariably go through a period of frothing at low solids concentration. A further increase in the solids concentration in the tanks seems to eliminate the frothing. In addition to the solids content, the kind of aeration, the air rate, and the aeration time will affect the frothing (9)(12).

Both Gowdy (4) and Wells (5) believe that when the mixed liquor contains a certain percentage of syndets, froth should be formed immediately if the detergents were responsible. However, since froth formation usually occurs after 2 to 3 hr. of agitation and aeration, they suppose that under certain conditions of aeration, particularly at low solids content, a material or compound is formed which causes frothing. It is a well-known fact that some proteins and glucosides, like the saponins, form the most stable foams in existence. Orland (7) presumes that butter fats and milk wastes may also give rise to froth formation.

Suppression of Froth

To counteract frothing in aeration tanks of sewage treatment plants three different methods are proposed.

Increasing Mixed Liquor Solids

On the strength of the foregoing facts it would seem possible to suppress frothing by increasing the solids content in the aeration tanks to a level which may differ from plant to plant (varying from 500 to 3,000 p.p.m.), depending on the type of plant and the operational conditions. If this

TABLE I.—Effect of Mixed Liquor Solids Concentration on Froth Formation

Investigator	Reference	Aeration Solids (p.p.m.)	Froth Formation	Remarks
Greeley	12	Low	Yes	At New York, Los Angeles, and Philadelphia.
Edwards	3	800–1,000	Yes	Frothing already noticed prior to syndets (1941).
Wells and Sherer	5,6	900–1,000	Yes	At San Antonio, Tex.
Anderson	2	1,250	Yes	At Cranston, R. I.
Mohlman	11	1,900	Yes	At Chicago, Ill.
Greeley	12	2,000	Yes	At Nassau County (N. Y.) plant.
Fuhrman and Rice	9	> 500	No	At Washington, D. C.; air rate, 0.5 cu. ft. per gal.; aeration time, 1.5 hr.; below 400 p.p.m. solids frothing occurs.
Gowdy	4	> 800	No	In mechanical aeration act. sl. plant with 100 p.p.m. detergent added. By reducing solids level (200 p.p.m.), easy to make froth even without detergents.
Wells and Sherer	5,6	>1,400	No	Possible to make or prevent froth at will by decreasing or increasing mixed liquor solids content in diffused air tank with 10 to 250 p.p.m. Tide added.
Hoot	11	>1,500	No	With solids below 1,500 p.p.m. frothing occurs; Philadelphia, Pa.
Anderson	2	3,000–3,500	No	Possibly requires additional air with increased loading; Cranston, R. I.
Kraus	7	3,000–5,000	No	Amount of froth about inversely proportional to solids in mixed liquor; high solids conc. and low air volume effective in controlling frothing; Peoria, Ill.

should meet with insurmountable difficulties, the use of a water spray system and anti-foam chemicals can be considered.

Use of Defoaming Agents

Various sewage plant managers have already had experience with anti-foam agents, either alone or in combination with a water spray system.

Brunner (7), for example, states that at Fort Wayne, Ind., an effective means of keeping down froth was by addition of 1 p.p.m. of kerosene, gasoline, or old crankcase oil directly to the liquid in the aerator. This method is truly a case of "pouring oil on troubled waters."

The same experience is reported at Motherwell, England, by McNicholas (2), who added small quantities of mineral lubricating oil (0.1 p.p.m.) to the aeration tank contents. According to him the defoaming agent Depuma * also effects a rapid disappearance of the froth.

Montgomery (7) reports violent frothing at the manhole where the trickling filter effluent dropped from the drain collector to a lower level for discharge. The filters were sometimes handling sewage with a fairly high mineral oil content. Segregation of the oil discharge from the filter effluent reduced the frothing action almost to the vanishing point.

Edwards (3) found that some defoamers as they go through the aerator lose their effectiveness after about 1 hr. by oxidation or adsorption on the activated sludge. Certain types of silicones and emulsified silicones were completely ineffective in a particular

* Manufactured by American Aniline Products, Inc., New York, N. Y.

case. The defoamers applied by Edwards did not have any harmful effect on the purifying action and the deposition of activated sludge.

In New York City and Los Angeles, Swift's Sanitary Defoamer † is applied for froth control.

Hoot (13) found that various defoamers were effective, but is of the opinion that they are too expensive for regular use.

Stevens (16) has carried out experiments with the defoaming agent S/V Foamrex W ‡ and obtained satisfactory results in concentrations of 0.5 to 1.5 p.p.m. in the sewage. This defoamer is added either in drops at one point of the aeration tank or mixed with water via a water spray system. Since the defoamer need not be added continuously, Stevens estimates the cost at $4.50 per day for a 50-m.g.d. plant. Berg (17) mentions a cost of approximately $0.50 to $1.00 per million gallons of sewage treated.

Use of Water Spray

According to Edwards (3), froth can be controlled simply by spraying water on it.

Donaldson (14) states that satisfactory control of severe frothing conditions at the New York City Sewage plants, has been provided by a permanent system of spray piping and equipment for injecting a controlled dose of one of several available antifoamers into the spray system when and where needed. Neither the spray nor an antifoam chemical alone has been found satisfactory, but the combination appears to provide a complete and economic control.

Los Angeles (18) also is considering construction of a water spray system for the control of froth at the Hyperion activated sludge plant.

Acknowledgment

The author wishes to thank the management of the N. V. Bataafsche Petroleum Maatschappij for permission to publish this paper.

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† Manufactured by Swift and Company, Hammond, Ind.

‡ Manufactured by Socony Vacuum Oil Co., New York, N. Y.

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INTERESTING EXTRACTS FROM OPERATION REPORTS

Attention operators! It will be appreciated if copies of all annual reports of both large and small plants are sent to the Federation office for abstracting in this section of the Journal. Carbon copies of typewritten reports will be promptly returned on request. Please direct annual reports to: Federation of Sewage and Industrial Wastes Associations, Room 325, Illinois Bldg., Champaign, Ill.

Annual Report of the Sanitary District of Indianapolis, Ind., for the Year 1952 *

BY DWIGHT O. BENDER, *Director*

The District is responsible for the operation of the sewage treatment plant; a garbage reduction plant; a power plant producing electricity, compressed air, and steam for both the sewage and garbage plants; a garbage and refuse collection division; construction and maintenance of intercepting sewers; and inspection and control of industrial wastes.

A multi-million dollar intercepting sewer and sewage plant expansion program begun in 1951 was continued throughout 1952. This work involves complete renovation and some enlargement of the primary sewage treatment plant and the secondary sewage treatment plant, plus construction of some new intercepting sewers and change-over from plant-produced to purchased power. Although much of the program was under the design and supervision of consulting engineers, many small components were designed by the District's Engineering Section.

* For last previous extract see *Sewage Works Jour.*, **19**, 1, 90 (Jan., 1947).

Power Plant

A study of the power plant showed that because of overloading plus the age and condition of the power producing equipment it would be more economical to discontinue power production and purchase the needed power. About one-half of the change-over was made in July 1951; the remainder, in March 1952.

The power plant also produces steam for heating all buildings on the grounds and to drive turbo-blowers furnishing air for the activated sludge process. Steam also was furnished for garbage processing until March, 1952, at which time the processing of garbage was discontinued.

Garbage Disposal

Operation of the garbage reduction plant was discontinued after February 21 because the steam pressure cookers, despite considerable maintenance work during 1951, had become dangerous to operate. Of the 32 cookers, 15 were condemned unconditionally. Major re-

pairs were required to put the remaining 17 back in service at reduced pressure. New replacement cookers had not been purchased because the decreasing return from by-products made garbage processing more and more expensive.

Currently, garbage is being disposed of by grinding and lagooning it with sewage sludge.

Refuse Collection

At the beginning of the year the refuse collection work schedule was changed from six days to five days per week. In addition, the color of the trucks was changed from gray to yellow for improved visibility, particularly on foggy mornings, in the hopes of reducing the accident hazard. The 67 collection vehicles (purchased in 1947) necessitated considerable maintenance work to keep them in operation.

Maintenance

Because of the advanced age of most of the equipment, the Maintenance Section was kept pretty well occupied with repair work. Nevertheless, several improvement projects were completed during the year. Among these projects were installation of 12 new replacement sewage meters in the secondary treatment plant, remodeling of one aeration unit for experimental work on processes, and construction of a by-pass in one of the major interceptors to scour out deep grit deposits that were decreasing the flow capacity.

During the year 151 stoppages were removed from connections between combined sewers and interceptors.

Industrial Inspections

A total of 683 inspections were made of filling stations, garages, meat packing plants, and industrial firms. In most of the 204 violations found, corrections were made on first notice. A noticeable decrease in packinghouse waste during the year was no doubt due mostly to the improved catch basins and grease recovery systems installed at two of the larger packing plants.

Sewage Treatment

About 75 per cent of the total sewage flow passes through screens and grit chambers at a river siphon some 3 mi. up-sewer from the treatment plant proper. The remainder is passed through a small grit chamber at the plant.

The primary treatment plant consists of 9 revolving drum-type fine screens which do not actually remove screenings but serve to divide the flow into (45 per cent) screened sewage and (55 per cent) "concentrated" sewage. This latter receives rapid (30 min.) settling before being passed to the aeration battery with the screened sewage.

The secondary treatment plant provides diffused air activated sludge treatment. The old diffuser plates are being replaced with aeration equipment of the swing diffuser type. Aeration tanks of both the 4-pass and 2-pass types are in use. Insufficient capacity of the primary plant results in a strong sewage being received at the secondary plant. Consequently, the overloaded secondary plant cannot perform at designed efficiency. Operating experience, moreover, has proved that maximum efficiency can be obtained by using a combination of the activated sludge and plain aeration processes.

Addition of five open sludge digestion lagoons in 1949 gave sludge disposal capacity estimated to be adequate until 1954. Cyclic operation of the sludge lagoons keeps them in service several years before cleaning is required.

Table I is a summary of the 1952 operating data.

TABLE I.—Summary of 1952 Operating Data, Indianapolis, Ind., Sewage Treatment Plant

Item	Average
Pop. served, est.	440,000
Rainfall (in.)	46.20
Sewage flow (m.g.d.)	68.7
Gal./cap./day	156
Grit removed (cu. ft./m.g.)	1.25
Primary treatment:	
Flow, fine screens (%)	46.6
Rapid settling (%)	53.4
Rap. clar., det. time (hr.)	0.55
Rap. clar., sol. rem. (%)	20
B.O.D., 5-day:	
Raw sewage (p.p.m.)	228
Raw sewage (lb./cap./day)	0.299
Primary sett. effl. (p.p.m.)	180
Fine screen effl. (p.p.m.)	241
Comb. prim. effl. (p.p.m.)	203
Act. sludge effl. (p.p.m.)	16
Plain aer. effl. (p.p.m.)	108
Final effl. (p.p.m.)	87
Reduction (%)	62.0
Removed (lb./m.g.)	1,175
Rem., act. sl. (lb./1,000 cu. ft./day)	30
Rem., plain aer. (lb./1,000 cu. ft./day)	23
Suspended solids:	
Raw sewage (p.p.m.)	241
Raw sewage (lb./cap./day)	0.312
Primary sett. effl. (p.p.m.)	148
Fine screen effl. (p.p.m.)	263
Comb. prim. effl. (p.p.m.)	194
Act. sludge effl. (p.p.m.)	24
Plain aer. effl. (p.p.m.)	71
Final effl. (p.p.m.)	59
Reduction (%)	76.0
Removed (lb./m.g.)	1,516
Rem., act. sl. (lb./1,000 cu. ft./day)	28
Rem., plain aer. (lb./1,000 cu. ft./day)	31
Sludge solids (%):	
Prim. sl., total sol.	3.8
Pl. aer. sl., total sol.	2.6
Ret. sludge, susp. sol.	1.16
Mixed liq., susp. sol.	0.25
Volatile solids (%):	
Raw sewage	69
Primary sludge	71
Pl. aeration sludge	65
Activated sludge	64
Plain aeration data:	
Sewage treated (m.g.d.)	52.1
Air (cu. ft./gal.)	0.44
Air (cu. ft./lb. B.O.D. rem.)	1,141
Aeration period (hr.)	6.4
Settling period (hr.)	2.2
Overflow (g.p.d./sq. ft.)	1,168
B.O.D. removed (lb./m.g.)	791
Activated sludge data:	
Sewage treated (m.g.d.)	16.6
Return sludge (m.g.d.)	4.8
Air (cu. ft./gal.)	1.47
Air (cu. ft./lb. B.O.D. rem.)	1,050
Aeration period (hr.)	7.1
Settling period (hr.)	2.9
Overflow (g.p.d./sq. ft.)	719
B.O.D. removed (lb./m.g.)	1,558
Ret. sl. susp. sol. (p.p.m.)	9,200
Mixed liq. susp. sol. (p.p.m.)	2,500
Sludge index	86
Return sludge ratio (%)	29
D. O. in aerator (p.p.m.)	3.6
River conditions:	
Flow (c.f.s.)	1,707
D.O. (p.p.m.):	
Above city	7.8
0.5 mi. above plant	5.3
6.25 mi. below plant	4.4
18.25 mi. below plant	3.9
30 mi. below plant	5.8
Operating costs ($):	
Labor, total	$180,301.65
Material, total	25,330.92
Power, total	222,029.62
Total	427,662.19
Per m.g. treated:	
Labor	7.17
Material	1.01
Power	8.83
Total	17.01
Stream control & intercept.	0.95
Grit chambers	1.08
Clar. and pumping	4.34
Sec. Treatment	10.12
Sludge disposal	0.53

Annual Report of the Plainville, Conn., Sewage Treatment Plant for the Year Ended August 15, 1954

By Theodore E. Fanion, *Operator*

About 70 tons of dried solids were drawn to the sand filter beds in the form of digested sludge. Ultimate disposition of this material presents no problem, as local demand exceeds the supply. All filter beds not in use were sprayed with weed killer, which is effective for a little more than a year.

TABLE II.—Summary of Operating Data, Plainville, Conn., Sewage Treatment Plant for Year Ended August 15, 1954

Item	Average	Item	Average
Pop. served, est.	4,440	Settl. sol., removed (%)	99.8
Rainfall (in.)	41.50	Dig. sludge data:	
Sewage flow (m.g.d.):		Moisture (%)	93.8
Average	0.338	Solids (%)	6.4
Maximum, instantaneous	1.560	Vol. solids (%)	52.8
Minimum, instantaneous	0.180	Alkalinity (p.p.m.)	1,875
Maximum, 24-hr.	0.490	Gas produced (cu. ft./day)	4,629
Minimum, 24-hr.	0.259	Cu. ft./cap./day	1.33
Grit removed (cu. ft./m.g.)	0.22	Chlorine used, total (lb.)	6,000
Raw sludge to dig. (g.p.d.)	954	Chlorine residual, effl. (p.p.m.)	0.5
Settl. solids, infl. (ml./l.)	15		

Besides cleaning the two primary tanks, tightening the collector chains, and removing the grit and stones from the hoppers, all exposed metal was painted. Also painted were the grit and comminutor chambers and the exteriors of all treatment plant buildings. The latter were showing signs of wear after four years.

The 75,000 g.p.d. pumped from the pumping station presents some problems, as the present suction arrangement (set to avoid air binding of the pumps) leaves about 5 in. of solids in the bottom of the wet well. Inefficient operation, plus sewage decomposition, results.

Table II is a brief summary of operating results.

RAW SEWAGE PUMPS *

By Charles H. Stratton

Superintendent, Rockaway Pollution Control Works, New York, N. Y.

New York City's pollution control plants use many pumps of several varieties. A few of the pumps and their uses are as follows:

1. Centrifugal pumps, the work horses of a sewage treatment plant. This type is used to pump sewage, sludge, effluent, and water.
2. Plunger pumps, used for materials containing a relatively large amount of solids.
3. Positive displacement rotary pumps, usually of the worm or gear type, used for handling oil.
4. Regenerative, peripheral, or turbine pumps, used to supply seal water to some of the centrifugal pumps and compressors, and for other functions requiring comparatively small quantities of water.
5. Diaphragm pumps, used for pumping small quantities of defoaming agents in combatting the froth that forms on the surface of the aeration and final tanks.
6. Air lifts, used in some plants in lieu of pumps for delivery of return sludge to the aeration tanks.

Satisfactory operation of the raw sewage pumps in the treatment plants is of major importance. If they do not function properly, the entire treatment is adversely effected.

Plant personnel are primarily interested in the operation and maintenance of these pumping units, be-

* Presented at a meeting of the Metropolitan Section, New York Sewage and Industrial Wastes Assn.; New York, N. Y.; May 25, 1954.

cause ordinarily the pumps are already installed when "Operations" enters the picture. Both the design of the pumping unit and the care exercised in its installation have great bearing on the trouble-free life of this equipment.

Design of unit includes not only the actual pump itself, but also the related structure and equipment (such as the wet well from which suction is taken; the piping to the pump, both suction and discharge, including fittings; the pump shafting; and its driving unit).

Most of the raw sewage pumps in the New York City plants are of the vertical centrifugal type. They are units of few and not too complicated moving parts, and the parts are comparatively large. However, the small differences in design and installation of the various pumps determine the maintenance required to keep them operating efficiently.

Bearings

The raw sewage pump bearings are a frequent source of trouble. Experience shows that if the pump bearings are readily accessible, easy to lubricate, of sufficient size to carry the required load, and of standard design—that is not of a fancy or trick type that may take upward of a year for delivery of replacement parts—very little trouble will result from their operation.

Bearings are more accessible if the yoke is of split-type construction. With this type of bearing support it is comparatively easy to replace either the thrust or radial bearing without removing the impeller from its casing, providing the thrust and lower bearing are designed to permit their removal in an upward direction. Bearings should be as simple and of as few parts as possible. At one of the City's plants the pump thrust bearing is an assembly of three sets of rollers, one above the other. In the two top sets, the plain untapered rollers roll and also slide or slip as they travel in horizontal planes. Lubrication, under these conditions, is difficult; either the lower rollers have too much grease or the top row is too dry. The life of these bearings is much too short. Another make or type of bearing cannot be used as the housing is too small to permit installation of any other bearing that will carry the required load except the one specific make. A complete new custom-made bearing support or yoke would be required if a standard-type roller or ball thrust bearing were to be installed.

Packing Gland

The packing gland for the pump's shaft should be easily accessible. Means should be provided for removing the water leaking along the shaft and accumulating around the packing gland, as is the case in some of the pumps installed. The danger of water travelling up the shaft and into the radial bearing is not to be passed over lightly. This could probably be prevented by water slingers.

Pump Clogging

Clogging of the eye of the impeller in the raw sewage pumps is not common. The bar racks ahead of the pumps remove the coarser materials from the sewage and the passages through the impeller are comparatively large. This, of course, is not true with smaller centrifugal pumps, where impeller clogging may be frequent.

Clogging of the wearing rings or seal rings can be and is troublesome. At the Rockaway plant, rubber articles get between the wearing rings, and exert a braking action as the pump rotates. This overloads the motor, necessitating shutdown of the unit. When this occurs, it is necessary to open the pump casing and pick or dig the material from between the rings. It is believed that a greater amount of seal water delivered under high pressure would prevent this trouble. This is now under investigation.

Seal Water

At the Rockaway plant there are four raw sewage pumps, one of 7.5-m.g.d., one of 10-m.g.d., and two of 15-m.g.d. capacity. Seal water was originally supplied to these pumps through a 3-in. header fed from a seal-water tank, which in turn was supplied with city water through a 1-in. float valve. On occasion it was found that the seal-water tank was empty, although the float valve was wide open. In this particular installation, an additional 2-in. line and float valve were added to supplement the original 1-in. line. After this was done it was possible to retain water in the seal-water makeup tank. This additional water, however, has not wholly solved the problem. Clogged rings are still experienced.

At the Hunts Point plant, where there are two 50-m.g.d., one 60-m.g.d., and two 70-m.g.d. pumps, the seal water is fed through a 1½-in. header from a seal-water tank having an effective capacity of 130 gal. The tank is supplied with city water through a 1¼-in. line and float valve. This plant experienced the same trouble with an empty seal-water tank as at Rockaway. Here, too, a 2½-in. supplementary water line is being installed to the seal-water tank. The rings in the Hunts Point pumps do not clog with rubber goods to any noticeable extent, but the grit that passes through these pumps has worn the rings in about 6,000 hr. of operation until the ring spacing is at least 9/32 in. Obviously, with this gap pump efficiency is falling off.

Shaft Alignment

The alignment of the pump shaft is of great importance. Poor shaft alignment causes bearing failures, which are both expensive and time consuming.

Bearing inspection of one of the Rockaway raw sewage pumps recently revealed that a radial or steady bearing was carrying the thrust load, which should have been carried by the thrust bearing. This trouble was corrected so that now the thrust load is on the proper bearing.

In addition, the pump shaft must be of sufficient size and made of a suitable steel to drive that specific pump load at the speed required. Excessive shaft whip in one New York City plant recently required replacement of the shafting by the pump manufacturer.

Shaft bearing housings should be doweled to their supports after correct alignment. This facilitates proper alignment after pumps are dismantled for repairs, or when corrections are required due to shifting of structures.

The value of the so-called "floating" shaft—a short length of shaft with a flexible coupling at each end—can be questioned. The principal use or value of this arrangement is to prevent trouble from shaft misalignment. If the shaft is properly aligned and kept in proper alignment, only two flexible couplings are required; namely, one at the motor end and one at the pump. With only two flexible couplings, all shaft weight should be carried on the thrust bearing which supports the shafting instead of putting shaft weight on the pump thrust bearing. Elimination of this additional flexible coupling would also make unnecessary the thrust button support used between the pump shaft and the floating shaft. Removal and replacement of worn out thrust buttons, which are used to keep flexible faces from rubbing on each other, is just another plant job that is expensive in man-hours.

Muff or compression couplings used to connect the separate pieces of shafting should be of the type using thrust collars so as to keep shaft length and shaft thrust as designed.

Piping

The suction line to and the discharge line from the pump should be of sufficient size to prevent excessive head

loss. A gate valve should always be installed in the suction line when there may be a positive head on the pump. This will allow the pump to be opened for inspection and maintenance. However, this gate valve in the suction is not installed in all plants.

Experience indicates that a cone check valve in the discharge line is much more satisfactory than a butterfly valve. The butterfly valve becomes clogged too easily and its action is much less positive than that of the cone check valve. The value of a gate valve in the discharge line of each pump also can be questioned, because these valves are seldom used. This is particularly true when cone check valves are provided. Installation of one gate valve in the common discharge header after the pumps is, as indicated by experience, sufficient for the repairs required on the cone valve. Few plant shutdowns would be required for this work.

Miscellaneous

The size and location of the suction bell in the wet well is of such vital importance that it should be given extra consideration in the design phase of a plant.

At the Rockaway plant, there exists a peculiar pump problem which has not as yet been solved. Specifically, delivery from the raw sewage pumps drops off as the pumps run. For example when a 15-m.g.d. unit is started it pumps at the rate of about 14 or 15 m.g.d. After the unit has operated for an hour, however, the delivery will have dropped to about 12.5 m.g.d., in spite of the level in the wet well remaining constant. As the pump continues to run, the delivery continues to decrease, this decrease in delivery being accompanied by a corresponding decrease in current taken by the motor. If the cone valve on the discharge line is closed and the pump is momentarily stopped and then put back in service, the initial pump delivery rate is restored. The total head, as indicated by the gages, is very close to the design valve and also does not increase as the pump runs. The motor speed stays constant.

Inspection of the inside of the pump and lines showed no clogging by foreign materials. It is believed, therefore, that the pump becomes air bound, and since there is no evidence that air is entering through the packing gland, it is assumed that the air enters through the suction line.

In this presentation there have been listed, of course, only a few of the varied problems relating to the raw sewage pumps. As answers to these problems or defects become known, their correction is immediately undertaken by the various operating groups involved.

SEWER STOPPAGES IN BRITAIN

In a recent report,* a Joint Committee † on Field Research into Drainage Problems divulged the results of its extensive survey on the design and performance of existing sewer systems in Great Britain. The survey had as its object the drawing of conclusions which would lead to more economical and efficient practice in this regard.

The report states that current British practice indicates a tendency to use the separate system rather than the combined system of sewers. In addition,

* Published by the Institution of Sanitary Engineers, 118 Victoria St., S.W. 1, London, England; price, 1s.

† Representing the Institution of Sanitary Engineers, the Building Research Station, the Institute of Plumbers, and the Sanitary Inspectors Association, all of Great Britain.

TABLE I.—Minimum Gradient Permitted for Sanitary Sewers

Type of Responding Authority	Gradient (1 in—)			
	4-In. Pipe	6-In. Pipe	9-In. Pipe	12-In. Pipe
Urban district	60	—	—	—
Borough	60	80	—	—
Borough	50	65	—	—
Borough	70	210	—	—
Borough	—	—	268	—
Borough	110	150	—	—
Borough	50	60	—	—
Borough	60	80	120	180
Borough	70	120	—	—
County borough	70	100	200	—
City	70	180	400	—
City	48	—	—	—
City	60	80	—	—
Military post	—	238	—	—

the use of the private sewer is increasing.

Another interesting point is that a more scientific approach to design is leading to an increase in the number of house connections made to 4-in. and 6-in. pipes; as many as 20 on one 4-in. pipe laid at a slope of 1 in 70, and 64 on one 6-in. pipe being cited. At the same time, economy is being effected by the use of flatter gradients than those obtained by rule-of-thumb methods, the extreme examples given being 1 in 110 for 4-in. pipes and 1 in 238 for 6-in. pipes (Table I). The use of intercepting traps except under special circumstances, is generally declining.

As regards performance of sewer systems the report notes that from the limited data available, even use of flatter gradients is not nearly as frequent a cause of blockages as is the use of intercepting traps (Table II). These devices constitute the single location at which the greatest number of blockages occurred. Other points at which blockages are liable to occur are manholes, junctions, and bends (Table III), although opinion was almost unanimous that blockages noted as "at junctions" actually were usually in the branch pipe close to the junction, and not in the junction itself.

Because the actual object starting the trouble often was washed away to the larger sewer without being observed, full information on this phase is difficult to assemble. Nevertheless the breakdown given in Table IV is believed to be representative. The sanitary towel certainly is the most frequent source of trouble in house connections and all but one official interviewed believed that sewers should not be expected to deal effectively with sanitary towels, and that every effort should be made to provide for their disposal by another method. Many blockages are caused by misuse of the sewer connections by householders and tenants, usually through ignorance of the systems' limitations.

Equally important are the "basic" causes of blockage, among which were reported the following:

1. Use of disconnecting traps of poor design.

TABLE II.—Frequency of Sewer Blockages

Group	Blockages per 100 Houses per Year		Total Replies	No. of Authorities Using			Prob. Freq.[2]
	Range	Av.		10*d* Gradients	Flatter Gradients	Interceptors[1]	
A	5 and below	2.4	17	12	5	4	40 yr.
B	5 to 10	7.1	13	10	3	8	14 yr.
C	>10	22	10	8	2	7	4.5 yr.

[1] Intercepting traps, in new work.
[2] Liability of blockage in one house once during period given.

TABLE III.—Location of Sewer Blockages

Location of Blockage	Total Replies (no.)	Portion of Total Blockages (%)	Under 30 Per Cent		Under 40 Per Cent	
			Replies (no.)	Average Percentage	Replies (no.)	Average Percentage
Manholes	37	16	31	9.5	—	—
Bends	40	13	36	9	—	—
Junctions	40	17.5	—	—	37	13

2. Too flat gradients; very flat gradients are sometimes used indiscriminately, without due regard to the particular flow conditions.

3. Use of pipes larger than necessary, which have not given the required depth of flow to render them self-cleansing.

4. More bends are sometimes used than are absolutely necessary, thus increasing the hazard of building-up of blockages.

5. Faulty design of invert channels in manholes; branches have sometimes been brought in at too acute an angle, against the flow to the main channel.

6. Fallen plastering from manhole walls.

7. Displacement of stopper of interceptor trap rodding riser, with consequent obstruction.

8. Inferior workmanship in the laying of pipelines, particularly with flat gradients.

9. Bad jointing of pipes. "Lipping" of the joint can be caused by uneven caulking of the yarn of other centering material, but the worst fault is its omission from joints. The importance of good workmanship (especially as to jointing) was mentioned in more than 40 per cent of all the survey replies.

TABLE IV.—Source of Blockages

Cause of blockage	Percentage of Total
Sanitary towels	37
Newspaper, etc.	23
Rags	11
Grease	5
Miscellaneous	24

10. Defective construction of manholes, including unsuitable bricks and covers, and poor plastering.

11. Faulty and insecure setting of bends at the bottom of soil pipes, as a result of which the collar of the bend is often fractured.

12. Use of straight pipes for curves. Sometimes attempts are made to negotiate large-radius curves with straight pipes, which results in the joints being slightly open on one side.

13. Entry of tree roots into pipes.

14. Subsidence (from mining or other causes).

Of the methods of clearing blockages reported, rodding was used in 70 per cent, plunging in 22 per cent, and flushing in only 3.5 per cent of the cases. In only 4.5 per cent of the blockages was it necessary to relay the pipe.

Information was sought as to the average time taken and cost incurred in clearing drain blockages, but owing to the wide variation in the estimated figures given, it was difficult to obtain a clear picture of the position.

A total of 9,580 blockages per annum were cleared for £8,250, giving an average cost of 17s. 3d. (about $2.45) each. When related to the 202,000 local authorities' dwellings concerned, the average annual cost per dwelling is 9.8d. (about $1.18). On the basis of housing estimates and sewer connections made as late as November 1953, the cost of removing sewer blockages in Great Britain probably approaches £500,000 ($1,420,000) per year.

TIPS AND QUIPS

Grease Removal

When Operator Theodore E. Fanion emptied the settling tank at the Plainville, Conn., sewage treatment plant to paint, clean, and tighten the chains, he found that household fats and grease had splashed and accumulated on the sidewalls above the waterline. The walls had to be cleaned before painting, but just scraping them was not satisfactory.

Removal of the grease was accomplished by use of Penetrex.* A solution of 1 lb. of the compound in 1 gal. of hot water was brushed on the greasy sidewalls, let stand for 10 to 15 min., then rinsed off under hose nozzle pressure. Three such treatments removed all the grease and scum and left the walls ready for painting. The same results can be obtained on greasy pumps and other equipment in cleaning them and preparing them for painting.

The same compound also has been used for cleaning greasy floors by wetting the floor, sprinkling on the powder, scrubbing with a brush or broom, letting the remover stand for 1 to 2 hr., then hosing the floor. Grease removal by this method is complete enough to leave the floor ready for painting.

New Heating Element

A new type of copper-clad electrical heating element is said to offer important advantages in ease of application, precision heat control, and wide application. Known as Heatflex,† the mineral insulated heating unit can be wrapped around almost anything, immersed in any solution non-corrosive to copper, or enclosed in any material. It can be formed on pipes and valves; on outside steps, walks, ladders and equipment; and in water seals on gas holders.

* Manufactured by MacDermid, Inc., Waterbury, Conn.

† Manufactured by Continental Electrical Equipment Co., Cincinnati, Ohio.

Welding Awards to Operators

John R. Szymanski, superintendent of the New Britain, Conn., sewage treatment plant, received a Third Place Award of $250 in a recent national arc welding competition sponsored by the James F. Lincoln Arc Welding Foundation (see THIS JOURNAL, **25**, 9, 1119 (Sept., 1953)). The Cleveland Foundation made the award as one of 191 given to persons in non-industrial business and service establishments who submitted papers describing how arc welding is or could be used in the operation or maintenance of the business or service. The 191 awards, totaling $13,500, were distributed in 43 states, Alaska and Hawaii.

Mr. Szymanski described how an extensive welding program had become an integral part of the over-all maintenance program at a modern sewage treatment plant. As an example, an arc welded replacement was made for a chemical feeder unit with a resultant saving of $440.

Ervin Hille, Water and Sewage Department of San Rafael, Calif., received a Fourth Award of $100 for describing welded repairs made to the main treatment plant's influent line. A description of arc welded steam points used by the Public Works Department of Anchorage, Alaska, won $100 for F. Weisgram and George Small. Nelson Fuller, Batavia, N. Y., Water Department, received $100 for a description of a safety clamp for pipe and a cyclone sand separator. Special pipe fittings were described by Lyman Ketcham of the Tacoma, Wash., sewage treatment plant for $100. A total of nine awards were made to men in water and sewage departments.

The Foundation sponsored the program to encourage study of how the

use of arc welding in business and service establishments where it is not normally widely used could raise the standard of living by reducing the cost of making and distributing goods and services.

Light Up

Darkness, or dimness, is synonymous with accidents in hazardous locations. This fact has made industry and commerce recognize the value of light in preventing prowlers and innocent trespassers. The safety feature of illumination alone warrants investment in good lighting and its nightly use.

Filter Cloths Destroyed By Mold

Mold contamination, according to the plant newsletter, completely destroyed the four vacuum filter wool cloths at Cincinnati's Little Miami sewage treatment plant when the filters were out of service for four months.

Moral: When such cloths are to be out of service over long periods, precautionary treatment with mold inhibitors (and moth inhibitors!) is a cheap investment.

Plastic Metal Coatings

Prevention of metal corrosion and abrasion, whether due to chemical, electrolytic, or mechanical action, is claimed for a new type of protective coatings now available. According to the manufacturer, Arbonite Corp., Doylestown, Pa., newly perfected techniques now make it possible to apply the uniform, seamless, rubber-like plastic sheath even to large items.

Qualified Operators

At least one sewage treatment plant superintendent thinks of his staff as more than just an operating team, but rather as trainees for more important assignments in the field, even if in plants other than his own. As a case in point, A. J. Wahl, Superintendent at Boise, Idaho, in his monthly plant newsletter points out that five of his "alumni" are now superintendents and operating sewage treatment plants for other municipalities. Also that two others are capable of assuming like responsibilities. In fact, he even helps his "boys" find better jobs, despite the knowledge that by so doing he'll have to start the training round all over again.

Close Call

That sewage gas is dangerous can be verified by Leonard Fischer, Superintendent of Water and Sewage, Stickney, S. Dak. According to *The Clarifier* (Vol. **19**, No. 3), he had an abrupt introduction to the Grim Reaper this spring when he attempted to draw sludge for the first time from the Imhoff tank of the town's new sewage treatment plant.

Because the valves did not have stem extensions, Mr. Fischer was in the valve pit operating the wheel when the thick sludge suddenly broke loose with the valve opened wide. In an attempt to close the valve before being flooded out, he was overcome by sewage gas. Before losing consciousness, however, he sensed something strange and managed to get up the ladder and roll out of the pit. Luckily, this saved his life, as there was nobody nearby to effect a rescue.

In this case only temporary disability resulted, and no fatality. For that, all concerned should be thankful. But the incident serves to illustrate the false economy of saving a few dollars by not extending the valve stem for operation outside an unventilated sludge pit, as well as the invitation of disaster by entering the pit without proper equipment and without adequate help standing by.

Reviews and Abstracts*

Public Health Aspects of Waste Disposal by Composting. By Clarence G. Golueke and Harold B. Gotaas. *Amer. Jour. Pub. Health*, **44**, 339 (1954).

A simple and reliable composting procedure for municipal refuse is reported by the Sanitary Engineering Division Research Laboratory of the University of California. Important steps in the process are grinding, stacking, aeration by turning, and regrinding. Compost is produced by aerobic thermophilic microorganisms in 10 to 20 days. No inoculums are required. Temperatures and proper turning of the piles destroy pathogens and insect eggs, larvae, and pupae. The final product has many characteristics beneficial to the soil and to growing vegetation.

H. P. O.

Fertilizer Value in Waste Disposal Methods. By Leroy W. Van Kleeck. *Amer. Jour. Pub. Health*, **44**, 349 (1954).

Dried or partially dewatered sewage sludge makes an excellent soil conditioner and a good, though incomplete, fertilizer. Heat-dried raw activated sludge is the best sludge product, both chemically and hygienically, although some odor may result from its use.

The reasons why more sludge is not used are discussed, as are the advantages and disadvantages of broad irrigation and sewage farming. Garbage composting, both alone and in connection with sewage sludge, is receiving more attention, although current practice leaves much to be desired.

H. P. O.

Sewage Works "Suffering from Old Age, Overwork, Estimate Cuts. . . ." *Surveyor*, **113**, 330 (Apr. 24, 1954).

Extracts from "Recent Work at Leicester Sewage Farm and Works," presented by S. J. Roberts to a meeting of the Midland Branch of the Institute of Sewage Purification, describing the means employed to improve the performance of the plant with a minimum of new capital expenditure. The 23 trickling filters are now divided into two groups, the first 15 treating settled sewage, and the other 8 receiving a 1:1 mixture of settled sewage and the effluent from the first group. Humus tanks have been deepened by raising the weirs, and have been changed from cross-flow to radial flow by relatively simple modifications. Cracking trickling filter walls have been reinforced with scrap cable.

Screenings are being composted with straw and other waste vegetation; raw sludge, after drying on tilled land, is likewise composted. After grinding, both products are readily sold locally.

M. C. Rand

Der Zellentropfkörper (Cellular Trickling Filters). By A. Bernhart. *Gesundh. Ing.*, **72**, No. 1/2 (1951): abs. *Water and San. Eng.*, **2**, 2, 46 (1951).

This unique type of trickling filter consists of many individual cells stacked in tiers about 7 ft. high. The cell units are of precast concrete, chemical resistant, shaped like a channel iron and placed horizontally with the flanges up. The space between the flanges is filled with coarse filter material; the channel web is perforated to allow trickling of the settled sewage from the top unit of the tier through the various lower cells to the bottom. The air space is about 50 per cent of the cubic content of the filter and is formed by placing the flanges of the adjoining cell units on top of the flanges of each tier, thereby creating air channels and complete aeration of the entire filter. This simple type

* Please send to Federation headquarters all periodicals, bulletins, special reports, etc., which might be suitable for abstracting in This Journal. Publications of public health departments, stream pollution control agencies, research organizations, and educational institutions are particularly desired. Address such material: Federation of Sewage and Industrial Wastes Assns., 325 Illinois Bldg., Champaign, Ill.

of filter requires no mechanical equipment or piping, permits heavy dosing, and is most suitable for treatment plants serving 50 to 1,500 people at minimum construction and operation costs.

PAUL A. UHLMANN

Die Behandlung Industrieller Abwässer (Treatment of Industrial Sewages). By G. MUELLER-NEUHAUS. *Technische Mitteilungen*, **47**, 163 (1954).

The author reviews the present status of industrial waste treatment and the necessity of water conservation by re-using the treated waste water after recovery of valuable chemicals used in the manufacturing process or removal of objectionable solids by primary settling with or without chemical pretreatment. This general discussion is restricted to the problems of the large industries of the Ruhr district connected with the production of coal, steel, and chemicals. High efficiency of settling tanks is of utmost importance. Short-circuiting of the influent to rectangular tanks can be diminished by the use of a number of tees discharging the wastes at right angles to the flow in the tank. Sludge disposal methods vary with the type and characteristics of the particular waste sludge. Dephenolizing plants are needed at coke plants before the wastes can be discharged to the receiving stream. Steel mill wastes can be treated to recover sulfuric acid and iron oxide and most of the cooling or process water can be re-used. Chemical industry wastes of organic and inorganic nature require special treatment for each type. Due to the magnitude of the industrial waste problem, only a general description of the various wastes is given in the lengthy and well-illustrated article. PAUL A. UHLMANN

Sludge Treatment and Pathogenic Organisms. By W. MÜLLER. *Gesundh.-Ing.*, **75**, 187 (1954).

Ascaris eggs are completely destroyed by thermophilic digestion. Mesophilic digestion requires detention for 6 months plus drying for 6 months, or drying for 2 months and storage for 4 months to destroy all *Ascaris* eggs. Heating sludge either before or after digestion for 2 hr. at 55°C. will obviate the long digestion and drying periods. PETER K. MUELLER

Progress in Digester Gas Production and Utilization in West Germany. By F. KIESS. *Der Städtetag*, No. 11 (Nov., 1953).

The production and various uses of digester gas of 49 German municipalities are discussed and tabulated for 1951. Total gas production amounted to approximately 544,000,000 cu. ft. Various uses amounted to the following respective quantities of crude gas in million cubic feet per year: methane production 307, gas company 166, motor vehicles 91, digester heating 86, and power production 18.

PETER K. MUELLER

Design of Storm-Water Tanks. By G. MÜLLER-NEUHAUS. *Gesundh.-Ing.*, **74**, 396 (1953).

A method for calculating capacities of stormwater tanks ahead of sewage treatment plants or pumping stations is described with examples. The several variables for flow, rainfall, infiltration, runoff, storm intensities, storm durations, etc., are generally as given in Imhoff's "Taschenbuch." The method is an adaptation of the cumulative flow curve method of calculating water storage reservoir requirements. PETER K. MUELLER

A Hygienic Problem of Agricultural Utilization of Dairy Wastes. By KURT HAACK (Hygene Institute, Gelsenkirchen, Germany). *Gesundh.-Ing.*, **75**, 226 (1954).

This paper is a discussion of tuberculosis transmission to cattle through spray irrigation of grazing land by dairy wastes.

PETER K. MUELLER

Influence of Pinnau and Kruchau Rivers on the Pollution of the Pagensond Side Channel of the Elbe. By F. LUCHT. *Gesundh.-Ing.*, **75**, 220 (1954).

This is a 1952 survey report on the effect of two polluted tributaries on a 6-km. side channel divided from the Elbe by Pagensond Island. PETER K. MUELLER

Effect of Phenols on Microorganisms in the River Pleisse. *Wasserwirtschaft-Tech.*, **4**, 125 (1954).

The Pleisse was surveyed from Leipzig to the Elster for 10 months to include periods of low, normal, and high flow. With

no D.O. and 20 p.p.m. stream volatile phenols, no life existed. When increased flow increased D.O. to 5.3 p.p.m. and decreased phenols to 4.3 p.p.m. the first protozoa and algae species appeared and increased in variety and quantity as phenols were reduced to 0.2 p.p.m. All life disappeared when new pollution increased phenols to 18 p.p.m. An increase from zero to 2.0 p.p.m. phenols generally decreased the variety and quantity of protozoa with no relation to the saprophytic classification. The following species survived the respective river phenol concentrations, in p.p.m.: *Paramaecium putrinum, Linotus fasciola,* 9.5; *Colpidium colpoda Glaucoma scintillans, Carchesium polypinum,* 6.6; *Paramaecium caudatum,* 5.0. According to laboratory tests these organisms tolerated phenolic compounds up to the following concentrations, in p.p.m.: phenols and cresols 300; pyrocatechin 150; resorcinol 600; phloroglucinol 650; pyrogallol 33; hydroquinone 6.0; phenol waste concentrate 13, of which 60 per cent was steam volatile, 6.4 per cent was hydroquinone, and 11.4 per cent higher unknown phenols. Increasing temperatures increased toxicity. pH up to 8.0 was tolerated, but NH_3 was toxic at pH above 6.5. Organic and mineral media studies indicated that protozoa do not utilize phenols directly, but that their quantity is dependent on that of phenol-metabolizing bacteria. The latter are primarily aerobic. PETER K. MUELLER

Modern Sewage Treatment. BY H. RHODE. *Gesundh.-Ing.,* **75,** 121 (1954).

Modern German designs of grit chambers, sedimentation basins, aeration tanks, and digesters are described.

PETER K. MUELLER

1953 Annual Report, New York City Dept. of Public Works. (1954.)

The 1953 Annual Report of the Department of Public Works of New York City lists 11 modern sewage treatment plants in operation, with a design capacity of 761.5 m.g.d., treating 667 m.g.d., and four old plants built prior to 1935. In addition, seven new plants and two extensions are in design or about to be constructed, with a total capacity of 666 m.g.d.

The total volume of sewage treated was 688 m.g.d. Of the 490 tons of dry solids captured per day, about 53 per cent were dumped at sea. More than 2,000,000 lb. of scum (grease) were sold for $5,200. A total of 1,025,000,000 cu. ft. of sludge gas was recovered, which produced 44,700,000 kw.-hr. of power. The total cost of maintenance and operation was $4,923,000 ($19.50 per m.g.), of which 60 per cent was for salaries and wages.

The total cost of the New York City program is estimated at $336,000,000, and the cost to date of plants in operation is $132,000,000. LANGDON PEARSE

There's No Water Pollution Here. BY A. D. MCRAE. *Oil and Gas Jour.,* **53,** 103 (July 12, 1954).

This paper describes the procedure at the Sarnia, Ont., refinery of Imperial Oil, Ltd., to remove contaminants before discharge into the St. Clair River, an international boundary. Contaminants are removed at the source wherever possible and biological oxidation is employed to remove residual phenolic material and other reducing compounds. Spent caustic soda and sour condensates are neutralized by flue gas and an overhead material burned as fuel. The recovered petroleum acids are either burned or sold to chemical companies as a basis for plastics or organic chemicals.

The solid material collected is dewatered and deoiled by centrifuges, the oil recovered, and the solids burned in a multihearth furnace.

Wherever possible, pipelines have been put in trenches or elevated above ground to reveal leaks. Circular-type separators are used instead of rectangular. The emulsions are broken down. Neutralization by flue gases is practiced. Eight diagrams show the procedures followed. Biological oxidation handles 500,000 g.p.d. of phenolic material.

The waste disposal plant is designed to handle 900 bbl. per day of tank bottoms, oil-separator bottoms, and emulsions from separators and slop tanks. Two 3,000-bbl. cone-bottom tanks collect various pumpable wastes, containing free oil, water-in-oil emulsions, silt, fine carbon, plus 80 per cent water.

A primary centrifuge handles material which cannot be pumped, removing 95 per cent of the solids containing 19 per cent oil and 15 to 40 per cent water. A secondary centrifuge handles the filtrate from the pri-

mary centrifuge. The value of the oil recovered will more than pay for the centrifuges in a year.

The dewatering and deoiling of sludge is of value in planning the disposal of refinery wastes to keep down the size of the incinerator, which has three stationary hearths. Preheated air enters at its top. About 25 tons per day are handled.

The objectives are to keep the phenolic content below an average of 2 p.p.b. and a maximum of 5 p.p.b. in the waters, following initial dilution. Apparently if plant effluents contain less than 20 p.p.b. of phenols, the conditions can be met. The pH of the effluent is to be maintained between 5.5 and 10.5 and the non-volatile oil content should not exceed 15 p.p.b.

LANGDON PEARSE

Pollution Control, A Symposium. *Oil and Gas Jour.*, **53**, 110 (Aug. 16, 1954).

I. Refinery Waste-Stream Survey. BY A. P. DENNIS, JR.—This article is based on a survey made for the Bayway Refinery of Esso Standard Oil Co. in Northern New Jersey, discharging into Arthur Kill, a tidal adjunct of New York Harbor.

II. Oil and Sludge Removal at Skelly's ElDorado Plant. BY W. L. PURCELL AND T. W. FERGUSON.—Refinery primary waste treating facilities, consisting of oil and sludge removal equipment, constitute a process separate and distinct from secondary waste treating facilities which remove undesirable solutes from waste water.

The authors describe in detail the procedure recently adopted at the refinery of the Skelly Oil Co. at ElDorado, Kans., in which the wastes were segregated. The current refinery waste water effluent averages about 1,500 g.p.m. (not including sanitary sewage). This is subject to oil removal and secondary treatment.

The capacity of the oil-water separator was set at 15,000 g.p.m.

Waste water with sludge from water softening processes is drained to sludge pits, which are of a size to hold three or four months' supply.

A batchwise emulsion-breaking process is operated with heat and demulsifying agents.

III. Chemical Flocculation of Refinery Waste. BY R. F. WESTON AND R. G. MERMAN.—Atlantic Refining Co. operates a 10,000-g.p.d. chemical flocculation waste treatment plant at its Philadelphia refinery. This reduces the effluent oil content below 30 p.p.m. The basic treatment includes oil separation, chemical flocculation, sludge dewatering, and sludge incineration. The waste water passes through an oil separator to neutralization and flocculating facilities and thence to the Schuylkill River. The wastes are neutralized by adding slaked-lime slurry and boiler feedwater treatment sludge. Aluminum chloride and alum may be added as coagulants and activated silica, clay, and lime slurry may be added as coagulant aids. The sludge produced is concentrated and pumped to vacuum filters. The cake is incinerated.

Such a plant requires about three acres and may cost, exclusive of land, from $2,500,000 to $5,000,000 (1953 basis).

The problems of operation and the results obtained are given, together with a flow diagram. LANGDON PEARSE

Microbiological Formation of Sulfide and Sulfur. BY K. R. BUTLIN AND J. R. POSTGATE. *Proc. Inst. Superiore di Sanita* (Rome), p. 126 (1954).

Sulfides are formed microbiologically (a) by the degradation of sulfur-containing amino acids and proteins, (b) as an intermediate in the biosynthesis of sulfur-containing amino acids and protein, and (c) as the end product of sulfate reduction.

The release of sulfide from amino acids and protein under anaerobic conditions is characteristic of many microorganisms. The reaction is one of hydroloysis brought about by the enzyme desulfydrase. In the case of cysteine the products are pyruvic acid, ammonia, and hydrogen sulfide.

In the production of sulfide in synthetic reactions it is believed that the sulfate is reduced to sulfide and converted to cysteine.

Sulfate reduction is brought about by a specific organism (*Desulfovibrio desulfuricans*) and is the major type of reaction producing sulfide. It has been demonstrated that this bacterium can utilize gaseous hydrogen in the reduction of sulfate, sulfite, thiosulfate, and tetrachloronate. Elemental or colloidal sulfur is either not reduced or is reduced extremely slowly.

Reduction of sulfates is greater in the presence of some carbon sources than with gaseous hydrogen. A wide variety of carbon sources can be utilized. Addition of yeast extract and sodium sulfide permits the utilization of a greater number of carbon compounds. Lactate is oxidized to acetate, CO_2, and sulfide, probably pyruvate forming an intermediate in the oxidation. The reaction resulting in the reduction of sulfate is to some extent independent of growth. Growth can take place in pyruvate or malate medium without a detectable amount of sulfate. Lactate oxidation requires the parallel reduction of sulfate.

The yield of sulfide from sulfate depends, in addition to the sulfate content and the amount of reducing agent, on a number of other factors.

Vigorous cultures produce 2,000 to 2,500 p.p.m. of hydrogen sulfide in a medium containing sulfate and lactate equivalent to 3,190 p.p.m. of medium sulfide. Larger concentrations of sulfate did not increase the final yield and lowered the rate of sulfide production. No toxic effect of this concentration of sulfide has been demonstrated. Nitrogenous supplements increased the rate of sulfide formation. Higher yields of sulfide are obtained by the addition of compounds of metals forming insoluble sulfides. The concentration of NaCl and temperature also affect the yield of sulfide. The rate of sulfide production is greater during the logarithmic phase of growth than in the stationary phase.

It is suggested that the microbiological reduction of sulfate may be used industrially for the manufacture of sulfur. Reducing substances that may be used include whey, molasses, lactic acid, distillery slop, or sewage sludge. The last material, supplemented with sulfate, gave yields of over 0.7 per cent sulfide sulfur.

Microbial formation of elemental sulfur from organic compounds is rare. *Beggiatoa* and *Thiothrix* accumulate sulfur inside their cells when grown on a medium containing sulfide. Colored sulfur bacteria also form sulfur photosynthetically under anaerobic conditions.

H. HEUKELEKIAN

On the Biological Activities Determining the Optimum Amount of Activated Sludges to Aerate. BY ISAMU HORASAWA. *Bull. Inst. Pub. Health* (Japan), **3**, 2–3, 48 (Dec., 1953).

The author attempts to show that there is a relationship between the surface area of activated sludge, loading, protozoan activity, and purification of sewage by the activated sludge process.

H. HEUKELEKIAN

Ammonia Base Sulfite Pulping. BY W. Q. HULL, B. C. SMITH, J. H. HULL, AND W. F. HOLZER. *Ind. Eng. Chem.*, **46**, 1546 (1954).

The ammonium-base sulfite process for pulping wood to obtain free cellulose or paper is a process that can be used to compete with or replace the calcium bisulfite process. The ammonium-base process has several advantages over the calcium-base process as far as pulp production is concerned, as well as advantages in less stream pollution per unit of paper produced. The digester liquor can be concentrated in multiple-effect evaporators, as it can in the magnesia-base sulfite process and the Kraft process. The concentrated liquor can be burned, with recovery of sulfur dioxide, or it can be spray dried for the development of by-products far easier than with any of the metal-base processes.

The plant described in the article was originally operated as a calcium bisulfite process plant. It is stated that the conversion is relatively simple and requires little modification of existing equipment in comparison with magnesia-base sulfite pulping, which can also reduce stream pollution by concentrating and burning the digester liquor.

At present, 15 paper mills are either using the ammonia-base sulfite process for pulping or are experimenting with its use. None of the plants was built originally for ammonia; the first plant was converted in 1945 and most of the conversions have taken place since 1952. R. S. INGOLS

Air Pollution Review 1949–1954. BY L. C. MCCABE. *Ind. Eng. Chem.*, **46**, 1646 (1954).

Forty-seven articles are critically reviewed. R. S. INGOLS

Continuous Recording of Organic Matter in Waste Water. BY R. KIESELBACH. *Anal. Chem.*, **26**, 1312 (1954).

A method has been developed for con-

tinuously determining dissolved organic matter in waste water and recording the concentration directly in parts per million of carbon. Concentration changes as low as 1 p.p.m. carbon can be detected. Initial response to a change in the waste discharge occurs with a lag of 10 min.; 67 per cent of the response is attained in the next 4 min. The process requires precipitation of the carbonates with barium, filtration of the sample, oxidation of the organic carbon with dichromate and acid at 250° C. with 4-min. contact. The carbon dioxide produced is stripped from the solution, the free chlorine and other impurities are removed, and the carbon dioxide is measured in a gaseous, differential, conductivity device.

The details of the device are given.

R. S. INGOLS

Radioactivity Assay of Water and Industrial Wastes with Internal Proportional Counter. BY L. R. SETTER, A. S. GOLDEN, AND J. S. NADER. *Anal. Chem.*, **26**, 1304 (1954).

Suspended matter is removed on a cellulose acetate membrane and counted in an internal proportional counting chamber directly. Soluble materials are obtained in a thin film on a metal dish by slow evaporation in the dish of a large sample (200 to 1,000 ml.) The accuracy of the technique was shown by the addition of material of known activity to several samples.

R. S. INGOLS

BOOKS, REPORTS, AND PAMPHLETS

Techniques of Plant Maintenance and Engineering 1954. Clapp & Poliak, Inc., 341 Madison Ave., New York, N. Y. 291 pp. Price, $7.50 (1954).

Comprises the proceedings of the technical sessions held concurrently with the 5th National Plant Maintenance and Engineering Show, held in Chicago, Ill., in January 1954.

Report on Water Pollution Control: Delaware River Basin—Zone 1. Publ. No. 363 (Water Poll. Series No. 63), USPHS, Washington, D. C. (1954).

Contains pollution data available as of January 1954 on that portion of the Delaware River watershed above Trenton, N. J.

Proceedings of the Third Annual Water Symposium on Water Pollution. Eng. Exper. Station Bull. No. 43, Louisiana State Univ., Baton Rouge, La. 46 pp. Price, $0.50 (1954).

Comprehensive Water Pollution Control Program for the Yakima River Basin. Publ. No. 292, USPHS, Washington, D. C. (1953).

Comprehensive Water Pollution Control Program for the Humboldt River and Central Nevada Basins. Publ. No. 294, USPHS, Washington, D. C. (1953).

Comprehensive Water Pollution Control Program for the Red River of the North Basin. Publ. No. 293, USPHS, Washington, D. C. (1953).

Comprehensive Water Pollution Control Program for the Mississippi-Des Moines-Skunk Rivers Basin. Publ. No. 314, USPHS, Washington, D. C. (1953).

Studies of Thermal Conductivity of Liquids. Part IV. A Literature Survey of Ultrasonic Velocities in Liquids and Solutions. BY BYRON C. SAKIADIS AND JESSE COATES. Eng. Exper. Station Bull. No. 46, Louisiana State Univ., Baton Rouge, La. 61 pp. Price, $1.00 (1954).

Proceedings of the 1954 Southern Industrial Wastes Conference. Manufacturing Chemists' Assn., Inc., 1625 Eye St., N.W., Washington 6, D. C. 205 pp. Price, $2.50 (1954).

Fire Hazards and Safeguards for Metalworking Industries. Tech. Survey No. 2, National Bd. of Fire Underwriters, 85 John St., New York 38, N. Y. 56 pp. (1954).

Proceedings of the 17th Annual Short Course—Water and Sewage. Bulletin No. 44, Eng. Experiment Station, Louisiana State University, Baton Rouge, La. (1954).

Book Reviews

Air Pollution Abatement Manual. Manufacturing Chemists Assn., 1625 Eye St., N.W., Washington 6, D. C. Price, $6.00 (1954).

Developed and released over a period of some three or four years as individual chapters, this authoritative manual is now available as a complete unit in loose-leaf form. The knowledge and experience of many experts in the field have been freely utilized, under the coordination of an outstanding group of committees and individuals, to make this a basic reference in administration and control of air pollution problems.

Chapter headings are as follows:

1. Introduction.
2. Terminology and Selected Data.
3. Community Relations.
4. Legislative Requirements.
5. Physiological Effects.
6. Sampling Procedures and Measuring Equipment.
7. Analytical Methods.
8. Meteorology of Air Pollution.
9. Dust and Mist Collection.
10. Gas and Vapor Abatement.
11. Evaluation of Data.
12. Bibliography.

Two semi-annual supplements have been published in the form of appendices to keep the bibliography up-to-date, and more are contemplated. H. P. O.

Water Supply and Waste-Water Disposal. By Gordon M. Fair and John C. Geyer. John Wiley & Sons, Inc., New York, N. Y. 973 pp. Price, $15.00 (1954).

Intended as a textbook for both students and practicing civil and sanitary engineers, this treatise presents for the first time many of the important advances which reduce water sanitation to an orderly process of calculation. To emphasize fundamentals, the authors have classified the subject matter according to principles or unit operations. The resulting integrated discussion of the applications of scientific principles and engineering techniques represents an entirely new approach to the material in this field. It stresses principles rather than practice, methodology rather than method, and rationality rather than rule of thumb.

The first 16 chapters deal with the collection and distribution of water and the collection and removal of waste water. The remaining 14 chapters deal with the treatment of water and waste water. The entire work contains illustrative examples in simplified form. A feature of the book is a special chapter on water chemistry by John C. Morris.

Although in no sense a handbook on engineering practice, the book may be widely used as a reference by practicing engineers. An appendix includes useful tables and a diagram that facilitates the solution of the Williams-Hazen formula for flow of water in pipes.

H. P. O.

Data Book for Civil Engineers—Volume III, Field Practice. Second Edition. John Wiley and Sons, Inc., New York, N. Y. 394 pp. Price, $7.50 (1954).

This complete revision of a 1947 book offers a special reference section on surveying, modern concepts of field soil mechanics, and practical methods of field erection. A valuable on-the-job general reference and check list for construction inspectors, the book is profusely illustrated and well indexed. H. P. O.

Industrial Inorganic Analysis. By Roland S. Young. Chapman and Hall, Ltd. (John Wiley & Sons, Inc., New York, N. Y.) 368 pp. Price, 36 *s* net (1953).

This book combines many years of experience in inorganic analysis into a handy reference work intended to give not only the detailed procedures involved, but also the theory and the interfering elements. It should be extremely useful in

combatting the tendency of new laboratory workers to become involved in routine and to lose the ability to make decisions quickly on choice of the most suitable analytical procedures for use with unknown samples.

The procedures for each element are detailed in a separate chapter, giving general background information, general analytical procedures, special procedures, and pertinent standard references.

H. P. ORLAND

Water Conditioning for Industry. By SHEPPARD T. POWELL. McGraw-Hill, New York, N. Y. 548 pp. Price, $9.00 (1954).

This book is intended to meet industry's growing needs for better quality of water with a thorough, modern treatment of all effective water conditioning methods, from simple to complex. Specific methods and types of apparatus are described in detail, with information on design features, control required for effective performance, installation and operation costs, and other facts to aid in efficient selection and operation for particular industrial users.

The comprehensive treatment includes a review of latest types of evaporation and deaeration equipment, treatment of water in recirculating systems, silica removal, and acidizing of equipment to remove deposits. Testing methods, calculations, and interpretation of test results are also covered in this practical water conditioning guide for plant and process engineers.

H. P. ORLAND

The Law of Revenue Bonds. By L. E. CHERMAK. National Institute of Municipal Law Officers, 726 Jackson Pl., N.W., Washington 6, D.C. 236 pp. (1954).

This volume is to present the basic concepts of the law surrounding the issuance of revenue bonds by states and local public corporations, provide a ready access to citations of the cases and writings embracing this field of law, and to assist lawyers in preparing for the issuance of revenue bonds. The book is authoritative and contains a table of books cited (5 pp.), pamphlets, law review, and other articles cited (6 pp.), law review notes cited (4 pp.), and a table of cases (29 pp.). The index (33 pp.) is detailed.

The test is presented in a clear, logical manner and should be of value to those considering the issuance of revenue bonds for any purpose, whether engineers or lawyers.

LANGDON PEARSE

Les Réseaux d'Égouts (Sewer Systems). By PIERRE KOCH. Dunod, 92 Rue Bonaparte, Paris VI, France. 348 pp. Price, 3.25 Fr. (1954).

In this textbook primary emphasis is placed on modern French sewer design practice, although many references are made to English and American developments. Subjects covered include rainfall and runoff; methods of calculating and estimating storm-water flow for storm sewer design; design of separate and combined sewers; and design of sewerage appurtenances, including pumping stations, pumps, force mains, siphons, special branches and junctions, storm overflows, and street inlets. An important chapter is devoted to methods of preparing and submitting a proposal for the design of a sewer system.

Five appendices deal with drainage of storm water (M. A. Caquot), variations in the maximum intensity of rainfall in the Paris region as a function of frequency and duration (H. Grisollet), general formulas for flow in storm sewers in the Paris region, cross-sections of oval or egg-shaped sewers, and a sample table for calculating storm sewer requirements. Several diagrams also are included to simplify flow and cross-section calculations.

Where official proclamations or instructions have been issued relating to design criteria applicable to the various subjects discussed, these have been incorporated into the text.

C. P. STRAUB

Manuel de l'Assainssement Urbain (Handbook of Municipal Drainage). By KARL IMHOFF (French translation and notes by PIERRE KOCH). 3rd Edition. 328 pp. 87 illus. Dunod, Paris, France (1955).

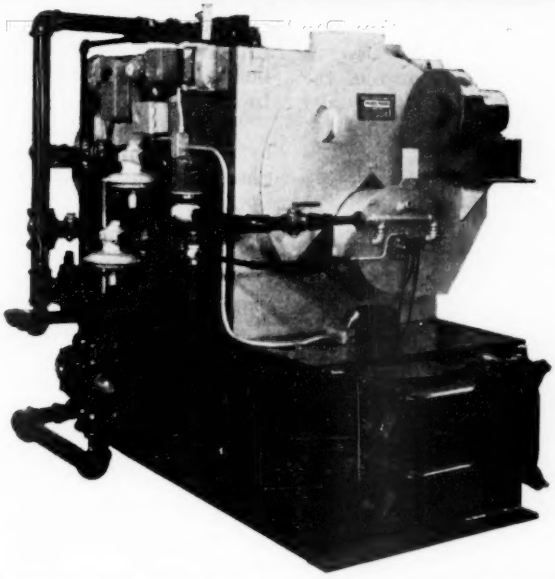
This is an annotated French translation of the well-known "Taschenbuch," now in its 15th Edition (see THIS JOURNAL, **26**, 5, 694; May, 1954). Special reference comments are made to French practice and standards in sewer design and sewage treatment.

H. P. ORLAND

WALKER PROCESS

HEATX UNIT

Digester Heat Exchanger



370,000 BTU/hr. HEATX for installation at Villa Park, Illinois. Burner automatically utilizes sewage gas or natural gas separately or in combination. A pre-ignition purge cycle clears the combustion chamber of any fuel accumulation before starting or between fuel switch-over.

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NO SLUDGE ADHESION

The HEATX is designed to allow absolute and independent control over each function of sludge heating; namely, heating of jacket water, control of temperature and flow of jacket water and control of digester temperature and rate of turnover.

The HEATX is offered as either a separate exchanger, for use with existing standard boilers or as a package unit complete with a Walker Process boiler and burner. Boilers are designed to burn sewage gas, sewage gas and oil or sewage gas and natural gas.

The concentric tube type exchanger is equipped with special removable end castings arranged to prevent contamination of the heating water by material circulated through the sludge tubes.

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Proceedings of Member Associations

CENTRAL STATES SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

The 27th Annual Conference of the Central States Sewage and Industrial Wastes Association was held at the Leland Hotel, Richmond, Ind., June 24–26, 1954. Registration for the meeting totaled 144, including 13 ladies.

Papers presented at the meeting were as follows:

"Vitamins in Dried Activated Sludge," by Bernard Wolnak, Miner Laboratories, Chicago, Ill.

"The Most Recent Developments in Sewage Gas Engines," by George L. Goodwin, Engine Specialist, Worthington Corp., Chicago, Ill.

"Experiences with a Regulation to Prevent the Accidental Discharge of Cyanide Solutions," by B. A. Poole, Technical Secretary, and Ralph H. Holtje, Chief, Industrial Wastes Section, Stream Pollution Control Board, Indianapolis, Ind.

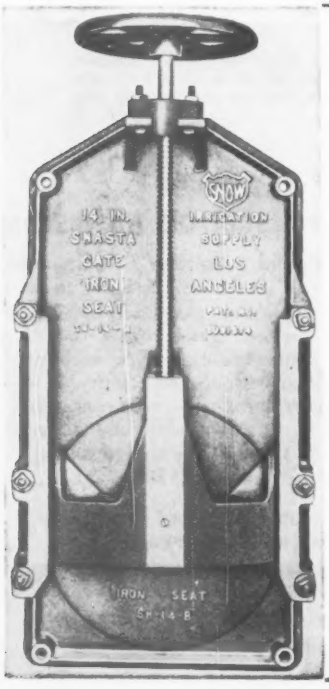
"Air Diffusion With Porous Tubes," by Miles Lamb, Manager, Sewage Engineering Department, Chicago Pump Co., Chicago, Ill.

"Simplified or Semi-Quantitative Tests for Sewage Evaluation," by W. D. Hatfield, Superintendent, Decatur Sanitary District, Decatur, Ill.

"Efficient Utilization of Digestion Capacity," by Philip F. Morgan, Professor of Sanitary Engineering, State University of Iowa City, Iowa.

The afternoon session on June 25 consisted of the annual business meet-

(*Continued on page 492a*)



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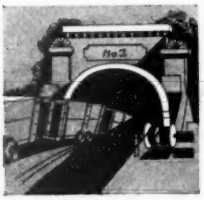
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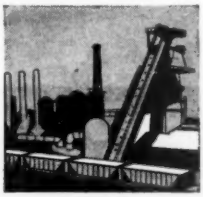
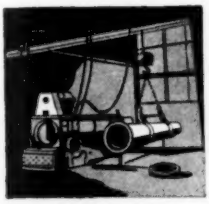

Blast Furnaces


Pipe Plants

ing, followed by an inspection trip to the Richmond sewage treatment works.

At the annual banquet, Henry R. King was awarded the Association's Gus Radebaugh Award for the best paper of 1953. Social hours preceding the annual banquet and the informal dinner on the previous evening were sponsored by members of the Water and Sewage Works Manufacturers' Association.

The morning session on June 26 consisted of an "Operators' Breakfast," in which open discussion on plant operation problems was stimulated and guided by a panel.

Officers elected for 1954–55 were:

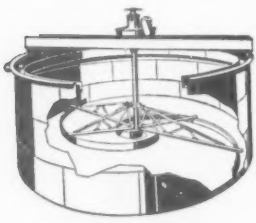
President: O. J. Muegge, Madison, Wis.
1st Vice-President: A. J. Duvall, St. Paul, Minn.
2nd Vice-President: W. E. Ross, Richmond, Inc.
3rd Vice-President: A. P. Troemper, Springfield, Ill.
FSIWA Director: M. L. Robins, St. Paul, Minn.
Secretary-Treasurer: G. F. Bernauer, Madison, Wis.

GEORGE F. BERNAUER,
Secretary-Treasurer

MICHIGAN SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

The 29th Annual Conference of the Michigan Sewage and Industrial Wastes Association was held in the Kellogg Center, Michigan State College, East Lansing, Mich., on May 25–26, 1954. This followed a one-day training course for sewage treatment plant operators sponsored by the Association and the Michigan Department of Health. A total of 238 men attended the training course and conference, with 39 ladies also registered. The training course featured discussions and demonstrations on operation

(*Continued on page 494a*)



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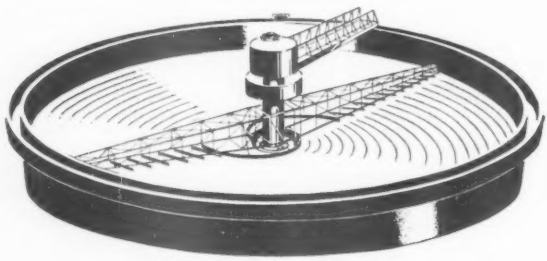
Hardinge Thickeners and Clarifiers have solved problems for the following industries with water treatment, waste-water disposal or by-product recovery difficulties: coal, paper, oil, glass, lime, stone, sand, carbon black, meat packing, rubber, domestic sewage and others. Write for information, giving details of your problem.

A distinctive Hardinge feature is the "Auto-Raise" driving mechanism, which automatically eliminates costly scraper breakdowns. Another feature is the double-spiral scraper which removes settled solids in one revolution.



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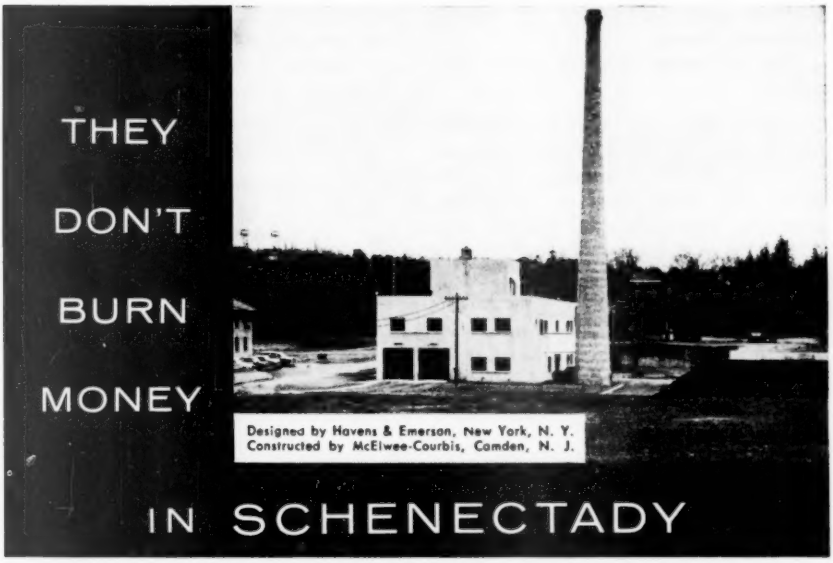

Instead, the new sewage disposal plant at Schenectady, New York, *saves* money—sizable sums accruing from the sale of Orgro—Schenectady's effective soil conditioner and fertilizer composed entirely of flash-dried sewage sludge.

As in many other communities, a C-E Flash Drying System has converted what would otherwise be a bothersome liability into a revenue-producing asset. By drying, packaging and selling its sludge, and then deducting all fuel, power, labor and bagging costs from the revenue received, Schenectady nets approximately $15.00 for each ton of dry solids sold. Thus far the demand for Orgro has been so great that an average week's production is sold at the plant in a matter of hours. During the winter months, when consumer demand may drop off, Orgro will be bagged, stored and kept ready for use the following spring on the city's parks and golf courses.

Had Schenectady elected to incinerate its sludge, not alone would all revenue be eliminated, but in addition, a cost of about $3.00 per ton would be incurred for ash disposal—a substantial item, since roughly 50% of the original dry weight of incinerated sludge remains as ash.

In communities where the character of the sludge makes it unsuitable for use as fertilizer, incineration may be the only answer. But in the many instances where these limitations do not apply, burning sludge may be equivalent to burning money.

Whether you plan to incinerate or dry, the C-E Raymond Flash Drying System allows you to do either at will. Like the communities listed at the left, you, too, can end your sludge disposal problems effectively and at less cost with the service-proved C-E Raymond System. For full information, contact the C-E Raymond office nearest you. A C-E specialist will be glad to help you. B-792A

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CITY	TREATMENT	NO. UNITS	SIZE OF UNITS Lb. Water per Hour per Unit	INSTALLED CAPACITY Tons Fertilizer Per Year
Baltimore, Maryland	Act. Dig.	3	6,140	29,800
Battle Creek, Michigan	Pri. Dig.	1	2,370	2,550
Chicago, Illinois				
Calumet	Activated	3	6,667	15,850
Southwest	Activated	8	21,000	148,500
Southwest Ext.	Activated	6	21,000	49,500
Edgewater, New Jersey	Pri. Dig.	1	795	150
Fond Du Lac, Wisconsin	Pri. Dig.	1	2,350	1,300
Houston, Texas	Activated	2	12,000	30,400
Lansing, Michigan	Act. Dig. & Garbage	1	6,667	6,780
Los Angeles, California	Act. Dig.	4	22,500	79,500
Recife, Brazil	Pri. Dig.	1	943	1,280
San Diego, California				
#1 Plant	Pri. Dig.	1	3,500	7,500
#2 Plant	Pri. Dig.	1	5,000	13,200
San Francisco, California	Pri. Dig.	3	6,250	35,400
Schenectady, N. Y.	Pri. Dig.	1	3,370	2,970
Sheboygan, Wisconsin	Pri. Dig.	1	3,040	3,060
Stamford, Connecticut	Pri. Dig.	1	3,330	1,780
Washington, D. C.	Pri. Dig. now Act. Dig. later	3	12,000	65,500
Wyomissing, Pennsylvania	Pri. Dig.	1	2,218	848

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ALSO FLASH DRYING AND INCINERATION SYSTEMS FOR INDUSTRIAL WASTE DISPOSAL

analyses and hydraulics of sewage treatment plants.

The following papers were presented:

"The Why of Water Pollution Abatement," by C. J. Velz, Professor of Public Health, University of Michigan; J. E. Vogt, Sanitary Engineer, Michigan Department of Health; and G. P. Manz, Michigan Asphalt Paving Association.

"Industrial Waste Problems Affecting Both Industries and Municipalities," by C. T. Mudgett, Director of Utilities, Muskegon, and T. J. Powers, Project Engineer, The Dow Chemical Co., Midland.

The Operators' Breakfast on May 26 was followed by a movie, developed at the Mount Clemens sewage treatment plant, showing the safety equipment installed for the control of gas hazards, and a discussion of general interest to the group.

Social events included a chicken barbecue on the Michigan State College campus one evening, and the Annual Banquet following a social hour.

Officers were elected as follows:

President: H. M. Leonhard, Wyandotte.

1st Vice-President: F. W. DuBois, Detroit.

2nd Vice-President: H. McEntee, Mount Clemens.

Secretary-Treasurer: D. M. Pierce, Lansing.

DONALD M. PIERCE,
Secretary-Treasurer

KENTUCKY–TENNESSEE INDUSTRIAL WASTES AND SEWAGE WORKS ASSOCIATION

The Eighth Annual Meeting of the Kentucky-Tennessee Industrial Wastes and Sewage Works Association was held in the Andrew Jackson Hotel, Nashville, Tenn., September 20–22, 1954, in conjunction with the Kentucky-Tennessee Section, AWWA. An all-time record of 294, including 61 ladies, attended.

Papers presented included the following:

"Construction of Nashville's Interceptor Sewers," by W. A. Coolidge, Director of Public Works, and Thomas B. Lee, Civil Engineer, Dept. of Public Works, Nashville, Tenn.

"Handling Plating Wastes," by F. W. Kittrell, Frederic B. Stevens, Inc., Detroit, Mich.

"Automatic Industrial Waste and Sewage Sampler," by W. B. Henderson, Tennessee Eastman Co., Kingsport, Tenn.

"Determination of B.O.D. by a Reaeration Technique," by Harold Elmore, Chemist in Charge, TVA Stream Pollution Control Laboratory, Chattanooga, Tenn.

"Some Factors Involved in Abatement of Industrial Pollution with

(*Continued on page 496a*)

No other book contains all this information on—

WATER SUPPLY
and
WASTE-WATER DISPOSAL

By GORDON MASKEW FAIR, Harvard Univ.; and JOHN CHARLES GEYER, The Johns Hopkins Univ.

With a special chapter on Water Chemistry by John Carrell Morris, Harvard Univ.

Set forth for the first time in this broad work are many of the important advances toward reducing water sanitation to an orderly process of calculation. In order to emphasize fundamentals, the authors have classified the subject matter according to the basic science or unit operation rather than according to the function performed by the complete systems. The resulting integrated discussion of the applications of scientific principles and engineering techniques is an entirely new approach to the material in this field, an approach which gives free rein to the exchange of ideas between the two subjects. The first half of the book deals with collection and distribution; the second half details the treatment of water.

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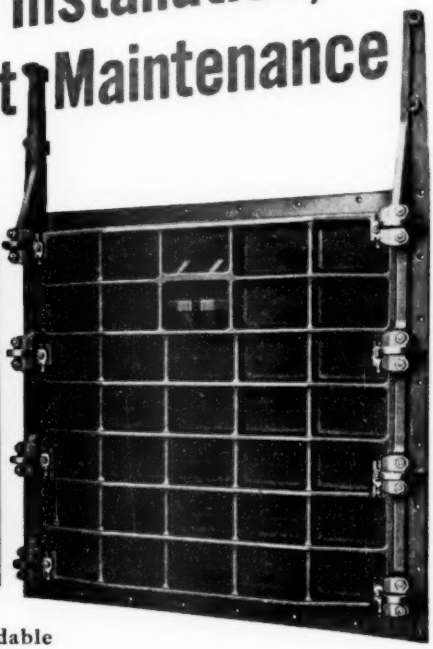

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Special Reference to Wastes from Viscose Processes," by W. J. Eldridge, E. I. du Pont de Nemours and Co., Old Hickory, Tenn.

"The Interceptor and Sewage Treatment Program of Knoxville," by L. C. Bailey, City Engineer, Knoxville, Tenn.

"Sludge Deposits in Stream Analysis," by W. C. Martin, Kentucky Water Pollution Control Commission, Louisville.

At the Business Meeting the following officers were elected to serve during 1954–5:

Chairman: R. P. Johnson, Lexington, Ky.
Vice-Chairman: C. M. Davidson, Chattanooga, Tenn.
Secretary-Treasurer: S. L. Jones, Nashville, Tenn.

S. LEARY JONES,
Secretary-Treasurer

MISSOURI WATER AND SEWERAGE CONFERENCE

The 1954 Annual Meeting of the Missouri Water and Sewerage Conference was held at the Hotel Governor, Jefferson City, Mo., on September 26–28, 1954, in conjunction with the Missouri Section, AWWA. Registration for the meeting totaled 291, including 16 ladies.

Papers presented included the following:

"Municipal Sanitation in Missouri," by L. E. Ordelheide, Executive Director, St. Louis Metropolitan Sewer District.

"Municipal Responsibility in the Conservation of Missouri's Natural Resources," by Jay Morrow, Assistant Director, State Conservation Commission, Jefferson City.

"Electrical Equipment for Sewage Treatment Plants and Sewage Pumping Stations," by E. O. Potthoff, General Electric Co., Schenectady, N. Y.

"Sewage Works Fire Protection and Factors of Fire Insurance Rating," by John E. Barman, Missouri Inspection Bureau, St. Louis.

"Sludge Filtration," by F. O. Barklage, Komline-Sanderson Engineering Corp., Omaha, Nebr.

"Reporting to the City Administration and Stockholders," by a panel comprising E. L. Filby, Black and Veatch, Kansas City; C. A. Green, Water Department, Kansas City; D. E. Crane, Superintendent, Department of Public Utilities, Fulton; and S. C. Casteel, Manager, East St. Louis and Interurban Water Co., East St. Louis, Ill.

"Service Extension Policies," by a panel comprising K. Mathews, Burns and McDonnell Engineering Co., Kansas City; V. C. Lischer, Horner and Shifrin, St. Louis; A. Learned, Black and Veatch, Kansas City; and C. A. Haskins, Haskins, Riddle and Sharp, Kansas City.

"Selection and Design of Sewage Treatment Facilities for Small Urban Communities," by L. J. Bremser, Black and Veatch, Kansas City.

"Catalytic Reduction Process for Accelerated Sludge Digestion," by T. H. Forrest, Chicago Pump Co., Chicago, Ill.

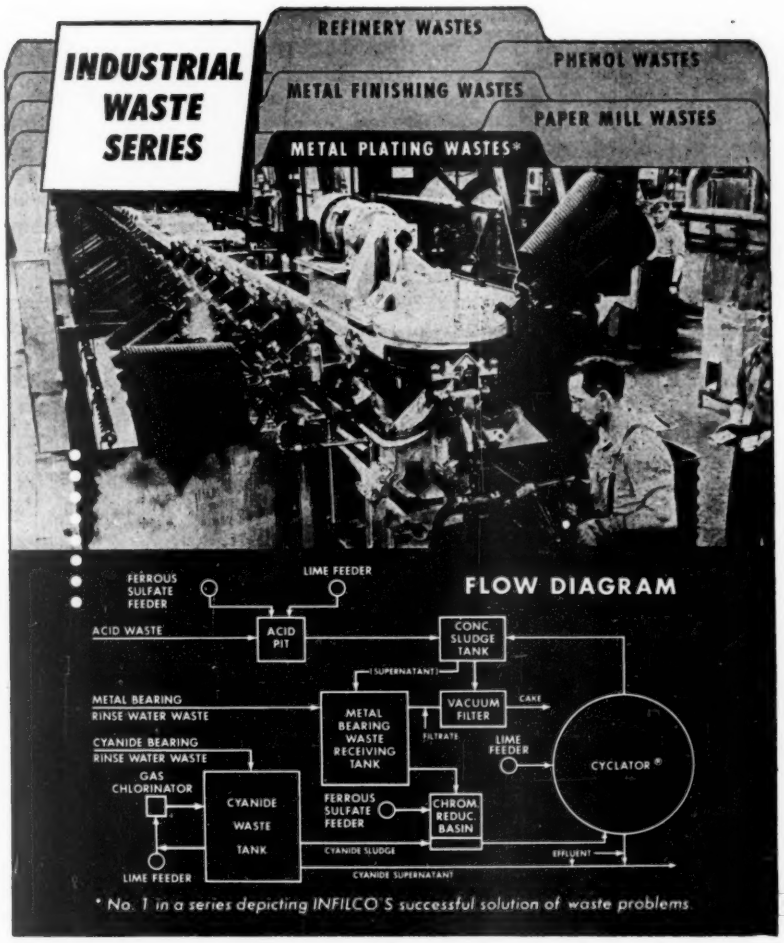
"Licensing of Water and Sewage Works Superintendents in New Jersey," by L. J. Fontenelli, Supervising Engineer, Rahway Valley Sewer District, Garwood, N. J.

Charles A. Haskins was announced as the recipient of the Federation's Arthur Sidney Bedell Award.

Officers elected to serve during 1954–5 were:

Chairman: C. S. Smith, Joplin.
Vice-Chairman: E. G. Lee, Lexington.
FSIWA Director (previously elected): J. K. Smith, Jefferson City.
Secretary-Treasurer: W. A. Kramer, Jefferson City.

W. A. KRAMER,
Secretary-Treasurer



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Liquid Level Control—Bulletin PF544 describes complete line of electronic liquid level controls suitable for general industrial use, particularly for the chemical, food processing, dairy, and sewage fields.—Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

Flow Meters—Catalog 2320 describes indicating, recording, integrating, and controlling flow meters of both evenly-graduated and square-root types.—Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa.

Asbestos Cement Pipe Coupling—New 6-page folder Tr–142A describes Ring-Tite coupling method of jointing Transite pressure pipe.—Johns-Manville, 22 East 40th St., New York 16, N. Y.

Gas Detector—Capable of detecting only a few parts per billion of various gases in air, a portable ultraviolet analyzer is also useable as a leak detector.—Manufacturers Engineering and Equipment Corp., Hatboro, Pa.

Fluid Controls—Bulletin 004 lists many types of equipment for the measurement and control of liquids and gases.—Simplex Valve & Meter Co., 68th and Upland Sts., Philadelphia 42, Pa.

Sump Pumps—New 20-page Bulletin No. 54–3–1420 contains selection charts and complete engineering information on sump pumps with capacities ranging from 10 to 2,600 g.p.m. at heads from 20 to 300 ft.—Byron Jackson Co., Box 2017, Terminal Annex, Los Angeles 54, Calif.

Temperature Controller—Bulletin 6430 describes new dual temperature controller.—Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa.

Instruments and Accessories.—Comprehensive coverage of a complete line of industrial instruments and accessories is contained in Catalog 5001.—Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa.

Loss-In-Weight Recorder—Bulletin 80–L13 describes a loss-in-weight recorder for dry feeders that indicates the weight of chemical left and indicates when hopper refilling is necessary.—Omega Machine Co., 345 Harris Ave., Providence, R. I.

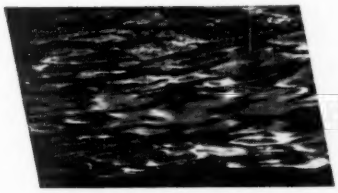
Telemetering System—A new telemetering system transmitting 30 signals over only two wires for remote control of water and sewage equipment is described in a special issue (Vol. 4, No. 2) of the *Rambler*.—Automatic Control Co., 1005 University Ave., St. Paul 4, Minn.

Coil Filter—Bulletin No. 102 describes and gives applications for coil spring vacuum filter.—Komline-Sanderson Engineering Corp., Peapack, N. J.

Incubator—Completely automatic incubator with range from 5° to 50° C., held within 1° C., will hold up to 160 standard 300-ml. B.O.D. bottles.—Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

Clay Pipe—Vitrified clay pipe is now being produced in 4-ft. lengths, in sizes from 8-in. to 24-in., both in standard and extra-strength types. Coupled with a new pressure joint, the longer pipe sections are claimed to effectively minimize infiltration and root penetration.—Robinson Clay Products Co., 65 W. State St., Akron 9, Ohio.

(*Continued on page 500a*)



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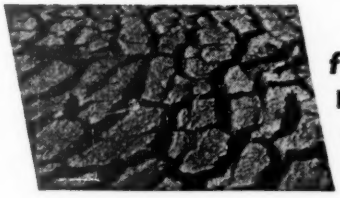

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Odor Control Compound—Bulletins 12 and 13 describe uses of Sanifil liquid compound for odor, insect, and rodent control.—Stewart-Hall Chemical Corp., 550 S. Fulton Ave., Mount Vernon, N. Y.

Demineralization—New 24-page Bulletin WC–111 on ion exchange principles and applications covers all phases of the subject.—Graver Tank and Manufacturing Co., Inc., 216 W. 14th St., New York 11, N. Y.

Ventilation Unit—New power exhaust unit utilizes positive air seal-off of the motor to eliminate corrosion and explosion hazards.—Gallaher Co., Omaha, Nebr.

Ball Valves—For service at pressures up to 150 p.s.i., ball valves in 12- to 48-in. sizes are described in Bulletin 159.—Valve Div., S. Morgan Smith Co., York 8, Pa.

Hose Couplings—New 16-page bulletin describes a line quick-seal, leakproof hose couplings.—Industrial Sales, Titeflex, Inc., Hendee St., Springfield 4, Mass.

Incubator—Designed to fit and match with unitized laboratory furniture, a new 4-cu. ft. laboratory incubator holds 50 standard B.O.D. bottles, plus providing a refrigeration compartment.—Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

Water Hammer Shock Absorber—Available in ½- to 2-in. sizes, a new shock absorber for water hammer cuts out vibration from that source.—Josam Manufacturing Co., Dept X51, Michigan City, Ind.

Floodlights—Bulletin 386–F describes in detail an aluminum one-pole assembly for effective floodlighting of heavy-duty service areas.—Crouse-Hinds Co., Wolf and Seventh North Sts., Syracuse, N. Y.

Engines—Bulletin S–500–B13C gives data and application information on diesel, dual-fuel, and gas engines.—Worthington Corp., Harrison, N. J.

Rotary Distributors—Complete design information on Walker rotary distributors is contained in Bulletin 23S70.—Walker Process Equipment, Inc., Aurora, Ill.

Wrought Iron Pipe—New 32-page bulletin gives technical data and installation information on wrought iron pipe lines.—A. M. Byers Co., Pittsburgh, Pa.

Asphaltic Coatings—Thermal, sound, and moisture insulations are described in new 8-page Booklet GM–100 dealing with application of asphaltic protective coatings in many fields.—Insul-Mastic Corp., 1141 Oliver Bldg., Pittsburgh 22, Pa.

D. O. Meter—A new, portable, self-contained, D. O. and oxygen uptake rate meter using the dropping mercury electrode makes rapid accurate determination of these factors.—General Laboratory Supply Co., P. O. Box 2607, Paterson, N. J.

Loss-in-Weight Recorder—Bulletin 50–L13 describes a loss-in-weight indicator-recorder for use with volumetric dry feeders.—Omega Machine Co., 345 Harris Ave., Providence 1, R. I.

Air Filter—A compact air filter designed to prevent foreign matter from entering pneumatic instruments is described in Technical Report T I29–A–29a.—The Foxboro Co., Foxboro, Mass.

Chemical Pumps—Rubber-lined pumps for corrosive and abrasive liquid service are described in a new catalog sheet.—Industrial Filter & Pump Mfg. Co., 5900 Ogden Ave., Chicago 50, Ill.

Portable Ventilator—Bulletin No. 1503–1 describes a new blower and exhauster for ventilation and smoke and dust removal work.—Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh, Pa.

Grinding Wheels—Catalog 1748 describes reinforced resinoid grinding wheels, mounted wheels and points, and sticks.—Norton Co., Worcester 6, Mass.

Dry Feeder—Bulletin 50–K57 describes a dry disc feeder, available with dustless loading hopper and scales.—Omega Machine Co., 345 Harris Ave., Providence 1, R. I.

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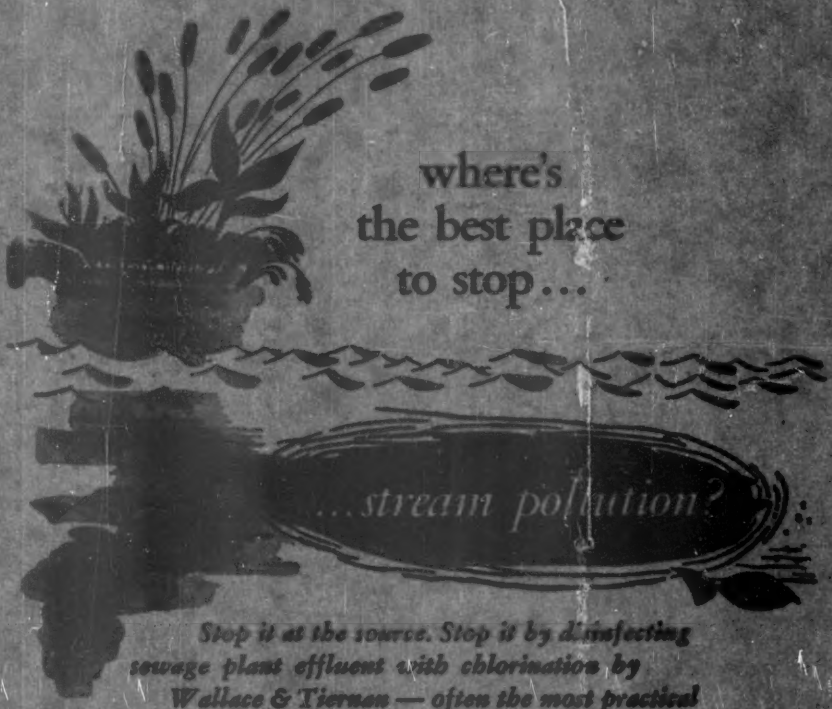

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